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PESTICIDES PROGRAM
National Communicable Disease Center

SUMMARY OF FEDERAL PESTICIDE PROGRAMS

Milton J. Foter, Ph.D., R.S., of the Program Office of the Bureau of State Services-Environmental Health, U.S. Public Health Service, discusses the problems involved in the increasing use of pesticides and the role of the federal government in programs to control the hazards involved in such uses.

Modern man is confronted with the choice of either continuing to gamble with the use of toxic chemicals or abandoning advantages of pest control in terms of abundance of food and the abatement of insect-borne diseases. This is our pesticides dilemma. It will remain with us until non-chemical means have been developed which will be effective in many more control situations than can be met by such methods today.

Although governmental resources of all kinds for coping with the pesticides problem are much greater now than at any time in the past, they are still inadequate to meet all our pressing needs. Progress is being made toward the solution of our dilemma but more support is needed for research, surveillance, training and technical assistance to assess the hazards to man's health.

It also should be noted that a high degree of coordination has been achieved among Federal departments having pest control and pesticide programs. This, too, is likely to become greater and most certainly can be described as progress since resolution of the pesticides problem uniquely requires an integrated attack.

The principal Federal mechanism for coordinating work in pesticides, as many of you know, is the Federal Committee on Pest Control (FCPC). The FCPC was brought into existence last summer under the aegis of the President's Office of Science and Technology as successor to the Federal Pest Control Review Board which had been scrutinizing hazards in Federal use of pesticides since 1961. It is composed, as was the Board before it, of representatives of the Departments of Agriculture, Defense, Interior, and Health, Education, and Welfare.

In its White House mandate, the FCPC was given three responsibilities in addition to that of annually evaluating Federal pest control programs in terms of risks versus expected advantages. These were (1) to develop a national program for monitoring and disseminating data on levels of pesticides in the environment; (2) to review pesticide and pest control research programs of the four departments for balance and effectiveness; and (3) to coordinate departmental pesticide informational and educational efforts. These new duties are being discharged by FCPC subcommittees.

There can be no question but what the FCPC and the Board have been strong influences in the reduction of hazards inherent in the dispersal of chemical poisons for the control of pests. At the very least, the Committee has provided a needed forum for the consideration and adoption of new and safer pesticides and application methods. It also has served as a link between Federal and State agencies in the introduction of new approaches to minimize environmental contamination harmful to fish, wildlife, farm animals, and man.

In the fire ant program, to take a specific example, the FCPC helped bring about substitution of baits containing a chemical of relatively low toxicity for general broadcasting of a more hazardous compound. The Committee's deliberations have effected comparable modifications

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in other programs and the outright withdrawal of still others. It should be pointed out, however, that the role of the FCPC is limited to coordination of Federal control programs. These represent less than five percent of the total national effort in pest control. It also can be stated, however, that FCPC recommendations have been adopted in all cases, although it has no mandatory authority.

Federal pest control operations have been authorized by Congress. Agriculture, for example, is required by law to suppress a great number of pests which otherwise would do hundreds of millions of dollars worth of damage to food and forage crops, rangelands, and forests. The Defense Department employs pesticides to control structural and other pests on military properties. Termites and other wood-eating insects, excessive aquatic growth, rangeland brush, rodents, prodators, and rough fish are among targets of Interior programs. The Public Health Service has a mandate to eradicate the Yellow Fever mosquito (*Aedes segypti*) in Florida and parts of Texas. It is programs such as these, all established by law, which the Federal Committee on Pest Control regularly scrutinizes.

More than a year ago, the Secretaries of Agriculture, Interior, and Health, Education, and Welfare took another historic step in the direction of pesticide activity coordination. They agreed in writing (1) that their respective departments would keep the others informed of new knowledge about pesticides and pest control from research and other sources and (2) that the Departments of Interior and HEW (PHS and FDA) are charged with the joint responsibility for the clearance of applications for pesticide registration as to their safety for man, fish, and wildlife prior to registration by the Department of Agriculture.

The second part of the agreement clearly was the more significant. It meant that Departments with primary responsibility for the health of people and their natural outdoor environment could participate for the first time in decisions affecting the manufacture and sale of pesticides which the Department of Agriculture only has the legal authority to make.

Under Federal law, every pesticide formulation must be registered with the U.S. Department of Agriculture before it can be sold in interstate commerce. Labels on pesticide containers must now bear Department of Agriculture registration numbers. When needed, key warning and cautionary statements must be displayed on the front panels of such labels and the nature and scope of safety claims must conform to proven facts.

Before registration is granted, a pesticide must meet rigid tests proving its claimed effectiveness against a particular pest or pests and demonstrating its safety to humans, crops, livestock, and wildlife when used as directed. A pesticide manufacturer often must undertake as many as three to five years of exacting scientific research to obtain proof of the safety and effectiveness of a single new pest control chemical. The adequacy of data covering animal toxicity tests and other experimental work must satisfy trained entomologists, animal biologists, pharmacologists, and other Department of Agriculture scientists. The judgment of these experts, many of them experienced researchers, often may be supported by results of work in the Department's own laboratories.

When research data accompanying an application for pesticide registration shows that crops or livestock treated with pesticide will contain a residue of the chemical at marketing time, the applicant is required to obtain a determination of residue tolerance from the Food and Drug Administration in the Department of Health, Education, and Welfare. In establishing the amount of pesticide which may be permitted in food products, FDA physicians, pharmacologists, chemists, and other scientists subject to the most critical examination data from animal toxicity and other tests conducted by manufacturers to demonstrate that residues will not be harmful to consumers.

No tolerances are allowed for cancer-inducing compounds. In fact, if all reasonable doubt about the safety of a pesticide cannot be removed by scientific testing, no tolerance is established and any amount of residue is in violation of the law. FDA tolerances often are one-

hundredth of amounts found not to have adverse effects on test animals and in no event are higher than the lowest levels which will accomplish intended purposes of the pesticides.

Trained FDA inspectors and scientists enforce pesticide tolerance rules. Compliance, to date, has been found to be high. As a further check on residue levels, the FDA conducts "total diet" analyses every three months in five widely separated U.S. cities. No more than traces of pesticides have been detected thus far.

Without doubt the greatest need, if the pesticides dilemma is to be resolved, is new knowledge of pesticides and new approaches to pest control. It is significant, therefore, and also encouraging, to note that Federal resources for research in pesticides and pest control not only have been markedly increased in recent years, but have been dedicated to a greater extent than ever before to finding satisfactory alternatives to chemicals for control of all kinds of pests. The new reliance on scientific investigation with new emphasis, incidentally, on basic research as well as non-chemical approaches to control, has become manifest in the Departments of Agriculture and Interior and in HEW agencies, including the Public Health Service.

As one instance of the trend in Federal pesticide research, more than two-thirds of Department of Agriculture research on insects now is aimed at developing new biological controls for major pests and basic information about insects.

The Department of Interior research similarly has been reoriented to exploit opportunities to take some of the risk out of pest control. Scientists in the Department are engaged intensively in a search for agents which will give effective control of pests with little or no harm to wildlife. At the same time, they are seeking to learn more about pronounced and subtle effects on fish, birds, and mammals of some of the presently available pesticides. They also are searching for improved methods for controlling aquatic weeds and for new techniques for a water analysis and surveillance of pesticides on public lands.

The new research efforts are beginning to produce results. Sex attractants are now being used to a limited extent in luring insects into traps. Reduction of insect populations through radiation and chemical sterilization, usually of the male, also is being achieved. In fact, this technique has been employed quite successfully against the screwworm, a once significant cattle pest, and several of the fruit flies. The use of biotic agents in the form of natural parasites or predators of serious insect pests also is making progress. Much of this work has been accomplished in the Department of Agriculture, but somewhat comparable successes in minimizing pest control hazards can be attributed to Interior Department investigators.

While such advances as these are heartening, it is necessary to point out that all sides frankly state that non-chemical control agents cannot yet approach the general effectiveness of chemical poisons. In truth, many scientists believe that we should not expect to avoid the use of chemicals entirely. They say that our best hope for the future lies in the development of integrated control systems. These would employ non-chemical methods in conjunction with applications of pesticidal chemicals.

Fundamentally, the responsibilities of Agriculture and Interior in the pesticides dilemma are limited to efforts to safeguard and improve what may be termed the health of our agricultural and natural outdoor environments. While these departments, to be sure, are concerned with the health of people, its protection is the primary responsibility, in the Federal government, of the Public Health Service.

The Public Health Service's capability for discharging this responsibility was measurably strengthened last November by establishment of the Office of Pesticides directly under the Assistant Surgeon General in charge of the Service's Bureau of State Services for Environmental Health. The basic objective of the Office is to develop procedures for remedying, minimizing, or preventing adverse human health effects from environmental contamination by pesticides.

The Office, as you would expect, is heavily research oriented. Its interest essentially is both in basic research on the toxicology of pesticides in experimental animals and man and in epidemiological investigations of possible associations between pesticide exposure and chronic human disease.

The Office of Pesticides now is supporting, in selected communities in ten States, the first large-scale scientific investigations ever made to determine whether pesticides may cause health effects in people after long occupational or general environmental exposure. The studies which will take five years or more to complete, are being conducted by or under the immediate direction of State and county health departments and academic institutions.

During the research period, investigators will make extensive analyses of surgical biopsy specimens or post mortem samples of human livers, kidneys, gonads, brains, and fat tissues to see if relationships may be found between pathological and physiological abnormalities and pesticide levels in food, water, air, and other environmental elements. Particular attention will be given to the pattern of disease incidences among persons occupationally exposed to pesticides.

The community studies are expected to fill many gaps now existing in our knowledge of human health effects of pesticides. Much of our present information is inadequate in that it is related to short-term human investigations, or animal toxicity tests, or to acute cases of poisoning resulting from heavy accidental exposures. These have limited relevance to long-term effects either from repeated heavy doses, such as pesticide workers may receive, or from minute amounts of pesticides which have been encountered by the general population in this country for years.

A few weeks ago, the Office of Pesticides arranged for the establishment of a Public Health Service Pesticides Research Laboratory at Perrine, Florida.

This facility will have responsibility for supervising the quality of the community studies of pesticides as well as Office-supported research in non-governmental laboratories. It also will provide essential technical backup for our recommendations on Department of Agriculture pesticide registration decisions. But the main task of the laboratory will be to conduct new scientific investigations.

One of the most pressing of pesticide research needs is to know more about chronic effects of pesticides over the life span of test animals. It is intended that the laboratory will fill this need and also that it will conduct research to find ways for more accurately extrapolating results of animal experiments to human experience. Currently available toxicity data simply are inadequate for making sound judgments as to the safety of existing pesticides, not to mention new ones appearing yearly.

More information is needed concerning the relative importance of various routes of intake, metabolism, storage and excretion of pesticides in man. Also relatively little is understood about the effects which pesticides and their metabolites may have on man either in combination with themselves or with other environmental chemicals man may ingest or absorb. Synergistic, additive, and antagonistic phenomena will be studied also.

As indicated, a great deal more must be learned about the subtle effects of minute environmental pesticide exposures —the so-called micro insults—as distinguished from gross manifestations of toxicity. The Public Health Service will do some basic work on methods for determining impacts of pesticides on individual cells in terms of delayed inductions of pathological - physiological changes which may be associated with the disease process in man as well as preliminary research on possible mutagenic properties of selected pesticides.

Studies to adapt modern techniques of chemical analysis to pesticide research requirements also will be made by the laboratory. As many of you realize, modern instrumentation and methods permit chemical measurements, at the molecular level. The Office of Pesticides must be able to capitalize on analytical advances.

The facility also must be in a position to lend technical support to surveillance in the Community Studies and Divisional Programs to determine the extent and significance of pesticide contamination of the American people and their environment.

Agencies represented on the Federal Committee on Pest Control have been working to design systems for continuously monitoring environmental levels of pesticides on a national basis. Meanwhile, the Office of Pesticides has begun to set up a National Pesticides Intelligence System. This eventually will collect, interpret, and periodically publish environmental pesticide exposure data and will disseminate information pertinent to the pharmacology and toxicity of pesticides.

Not all Public Health Services pesticide activities are conducted in the Office of Pesticides. For example, the Communicable Disease Center, a research arm of the PHS Bureau of State Services—Community Health, has been doing outstanding work in pesticides toxicity for more than 20 years. Significant pesticides research, some of it related to carcinogenicity, is being conducted and supported by the National Institutes of Health.

The Division of Water Supply and Pollution Control, now the Water Pollution Control Administration of Interior has been making full-scale investigations of water contamination by pesticides since 1959. Some of the most significant work done anywhere on identification of and methods for safeguarding against pesticide contamination of milk and food has been accomplished by the Division of Environmental Engineering and Food Protection, another Bureau of State Services agency. Pesticides research also is either performed or supported by the Bureau's divisions of Air Pollution and Occupational Health.

Recognition must be made of the work of State agricultural experiment stations, universities, State and local health departments who have active research, monitoring, training, and regulatory programs. While much of this work is being conducted through the research and training grants programs, and contracts supported by Federal Departments, the States themselves are beginning to give support to their individual pesticide programs.

Recognition must be made of the contributions made by industry which include the development of new, specific and efficient pesticides, improvement of existing pesticides, perfection of relatively safe replacements for the more potentially hazardous chemical agents, toxicology research, and development of methods of analyses.

It seems quite clear that the sanitarian working in pesticides today often will find himself in contact with representatives of many government agencies. Contrary to an impression we may have given you here today, more of these agencies are likely to be State and local than Federal. Their responsibilities and functions may not always be clear. It is anticipated that lines of authority may be clarified by efforts now being made in the States to correlate pesticide and pest control work somewhat in the manner employed in the Federal Committee on Pest Control. Of the fifty States and territories, some 16 States now have functioning interagency boards or committees for coordinating pesticide programs. To the best of our knowledge, only eight of these have representation from State Health Departments. However this may be, all of us may be sure that the pesticides problem now is widely recognized as a major national challenge which only can be met with the very best pooling of resources that can be achieved.

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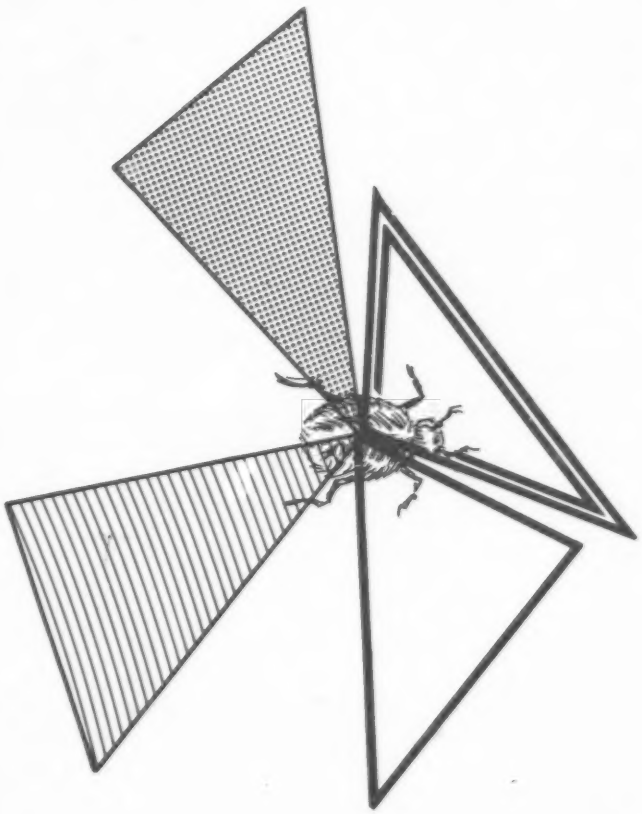
CDC

PESTICIDES OF PUBLIC HEALTH SIGNIFICANCE



U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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PESTICIDES OF PUBLIC HEALTH SIGNIFICANCE

Tens of thousands of chemicals have been evaluated for insect-, rodent-, weed-, and fungus-control. Hundreds of these are in daily use in the pest control field, and additional materials are being developed continually. As a result, even individuals engaged in pesticide research find it difficult to stay abreast of this vast and rapidly changing field.

Essential to comprehension of pesticides is an organized knowledge so unfamiliar chemicals can be associated with known materials and present background of knowledge can be used as a basis for understanding the new chemicals. As advances are made in pesticide knowledge, greater understanding of their toxicity to mammals is obtained. It should be emphasized, that degree of toxicity cannot be determined by the relative position of the pesticides in the charts. With any pesticide, all necessary safety precautions should be taken.

The following four charts present 350 of the most commonly used pest control materials in a practical system based upon a combination of chemical structure and pest control effect.

GLOSSARY OF TERMS AS USED ON THE CHARTS

ALGICIDE - chemical which kills algae

ANTICOAGULANT - rodenticide which kills by interfering with blood clotting

ATTRACTANT - chemical which draws an animal to a place

AUXILIARY - chemical without pest control effect used in pesticide formulation

BINDER - a substance used to hold rodenticide bait material together

BUFFER - substance added to herbicides to control acid-alkalai balance; protects herbicide from deterioration; enhances herbicidal effect

CONTACT POISON - insecticide which kills upon contacting the outer body surface of an insect

DEODORANT - material masking or destroying odor

EMETIC - chemical causing vomiting; added to rodenticides for safety

EMULSIFIER - chemical which suspends a pesticidal solution in water

FUMIGANT - pesticide which kills upon being inhaled

FUNGICIDE - chemical which kills fungi

HERBICIDE - chemical which kills weeds and other plants

IMPREGNANT - insecticide or repellent infused into clothing or other material

INHIBITOR - chemical which prevents insects from detoxifying an insecticide

INORGANIC - chemical compound not containing carbon

INSECTICIDE - chemical which kills insects and related animals

MOLD INHIBITOR - chemical which prevents mold development in rodenticide baits

NATURAL - found in nature, not synthesized by man

NON-SELECTIVE - kills all types of plants

NON-SUBSTITUTED - organic compound made up of only carbon and hydrogen and sometimes oxygen

ORGANIC - chemical compound containing carbon

REPELLENT - chemical which keeps an animal away from an individual, object or area

RODENTICIDE - chemical which kills rodents and related animals

SELECTIVE - kills only certain types of plants; does not harm other types

SOLVENT - liquid used for dissolving chemicals

SPREADER - substance which distributes pest control chemical through a greater volume

STERILANT - herbicide which kills all plant life in soil

STOMACH POISON - insecticide which kills upon being eaten

SYNERGIST - chemical without pest control effect which enhances the effectiveness of a pest control chemical

SYNTHETIC - manufactured by man; not found in nature

WETTING AGENT - chemical which helps suspend a pesticidal dust in water

NOTE: Use of trade names does not indicate endorsement by the Public Health Service. Incorporation of chemicals in these charts does not necessarily imply that the Communicable Disease Center has evaluated all of these materials. For example, herbicides and economic fungicides have been little studied by the Center due to their relatively minor role in communicable disease control.

THE CHEMICAL CONTROL OF INSECTS

INSECTICIDES

REPELLENTS
- Diethyltoluamide
- Indalone
- Rutgers 612
- Dimethylphthalate
- Dibutylphthalate

ATTRACTANTS
- Geraniol
- Eugenol
- Tetrapinylacetate
- Anethol
- Metaldehyde
- Ammonia
- Saccharine

IMPREGNANTS
- Benzil
- Benzylbenzoate
- Benzocaine
- M-1960
- Mitin
- Eulan
- Beconizer

AUXILIARIES
- Synergists
- Inhibitors
- Solvents
- Emulsifiers
- Wetting Agents
- Spreaders
- Perfumes
- Diluents

Contact Poisons

INORGANIC

SULFUR GROUP	MERCURY GROUP
Sulfur	Calomel
Lime-sulfur	Corrosive sublimate

ORGANIC

Synthetic

NON SUBSTITUTED HYDROCARBONS	ORGANIC CHLORINE GROUP*	ORGANIC PHOSPHORUS GROUP	ORGANIC NITROGEN GROUP	ORGANIC SULFUR GROUP	ORGANIC THIOCYANATE GROUP
Formaldehyde	Pentachlorophenol	Malathion	Dinitrophenol	Aramite	Lethane
Metaldehyde	BHC	Diazinon	DNOC	Ovex	Thanite
b-Naphthol	Lindane	Parathion	DNOCHP	Sulfenone	Loro
Xanthone	Methoxychlor	TEPP	DNOSBP	Phenothiazine	
Ferbam	DDD	EPN	Diphenylamine	Genitol	
	DDT	HETP	Azobenzene	Sevin	
	Dilan	DDVP	Karathane	Isolan	
	Dimite	Dibrom	Prolan	Dimetilan	
	Heptachlor	Guthion	Dinitronaphthol	Pyrolan	
	Chlordane	Dipterex	Dinitroanisole		
	Aldrin	Entex	Dinitrocresylate		
	Dieldrin	Baytex			
	Endrin	Ronnel			
		Dicapthon			
		Dimethoate			

*Chlorinated Hydrocarbons

Natural

PETROLEUM GROUP	ALKALOID GROUP	ESTER GROUP	ROTENOID GROUP	RESIN GROUP
Fuel Oil	Nicotine	Pyrethrum	Rotenone	Phelledendrin
Kerosene	Anabasine	Pyrethrins		Croton Oil
	Nornicotine	Cinerins		Amorphin
	Sabadilla	(Allethrin)		Basil Oil
	Hellebore			Sage Oil
	Ryania			Turpentine
	Quassia			

Stomach Poisons

ARSENIC GROUP	FLUORINE GROUP	OTHER GROUPS
Arsenic trioxide	Sodium fluoride	Phosphorus paste
Lead arsenate	1080	Borax
Copper arsenate	Cryolite	Tartar emetic
Paris green	Sodium fluosilicate	SALP
		Thallium sulfate

Fumigants
- Hydrogen cyanide
- Methyl bromide
- Carbon tetrachloride
- Ethide
- Sulfur dioxide
- Naphthalene
- o-Dichlorobenzene
- p-Dichlorobenzene

HAROLD GEORGE SCOTT, Ph.D.
1962
DHEW, PHS, CDC

THE CHEMICAL CONTROL OF RODENTS

RODENTICIDES

REPELLENTS

- Cefro
- THBA
- DR-1669
- TMTD
- ZAC
- Phenyl-nitropropene
- n-Butyl-phthalimide

ATTRACTANTS

- Anise
- Fish
- Meat
- Grain
- Fruit
- Nuts
- Molasses
- Water

DEODORANTS

- Isobornyl acetate
- Neutroleum alpha
- Pine oil
- Peppermint oil
- Wintergreen oil

AUXILIARIES

- Binders
- Emetics
- Decolorizers
- Mold inhibitors
- Solvents

SYNTHETIC POISONS

INORGANIC

- Zinc phosphide
- Arsenic trioxide
- Arsenic pentoxide
- Thallium sulfate
- Barium carbonate
- Yellow phosphorus

ORGANIC

ANTICOAGULANTS GROUP

HYDROXYCOUMARIN SERIES	INDANEDIONE SERIES
Warfarin Warfacide Prolin	Pival Pivalyn
Fumarin Fumasol	PMP
Tomorin	Diphacin

OTHER GROUPS

- ANTU
- 1080
- DDT
- Endrin

NATURAL POISONS

- Red squill
- Strychnine
- Hellebore
- Physostigmia

FUMIGANTS

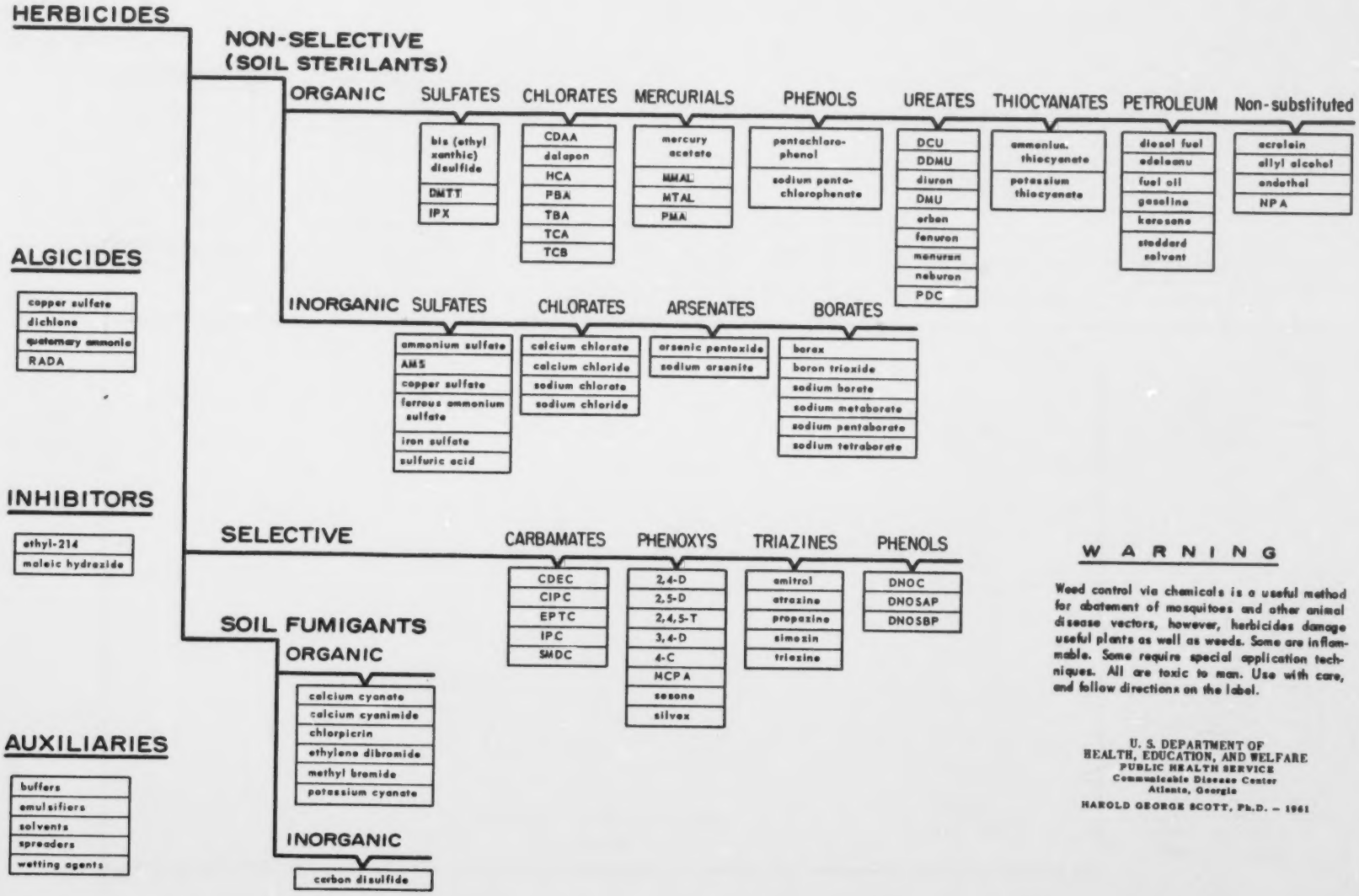
INORGANIC

- Sulfur dioxide

ORGANIC

- Hydrogen cyanide
- Methyl bromide

PREPARED BY
Harold George Scott
REVISED 1964
DHEW, PHS, CDC



W A R N I N G

Weed control via chemicals is a useful method for abatement of mosquitoes and other animal disease vectors, however, herbicides damage useful plants as well as weeds. Some are inflammable. Some require special application techniques. All are toxic to man. Use with care, and follow directions on the label.

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PUBLIC HEALTH SERVICE
Communicable Disease Center
Atlanta, Georgia
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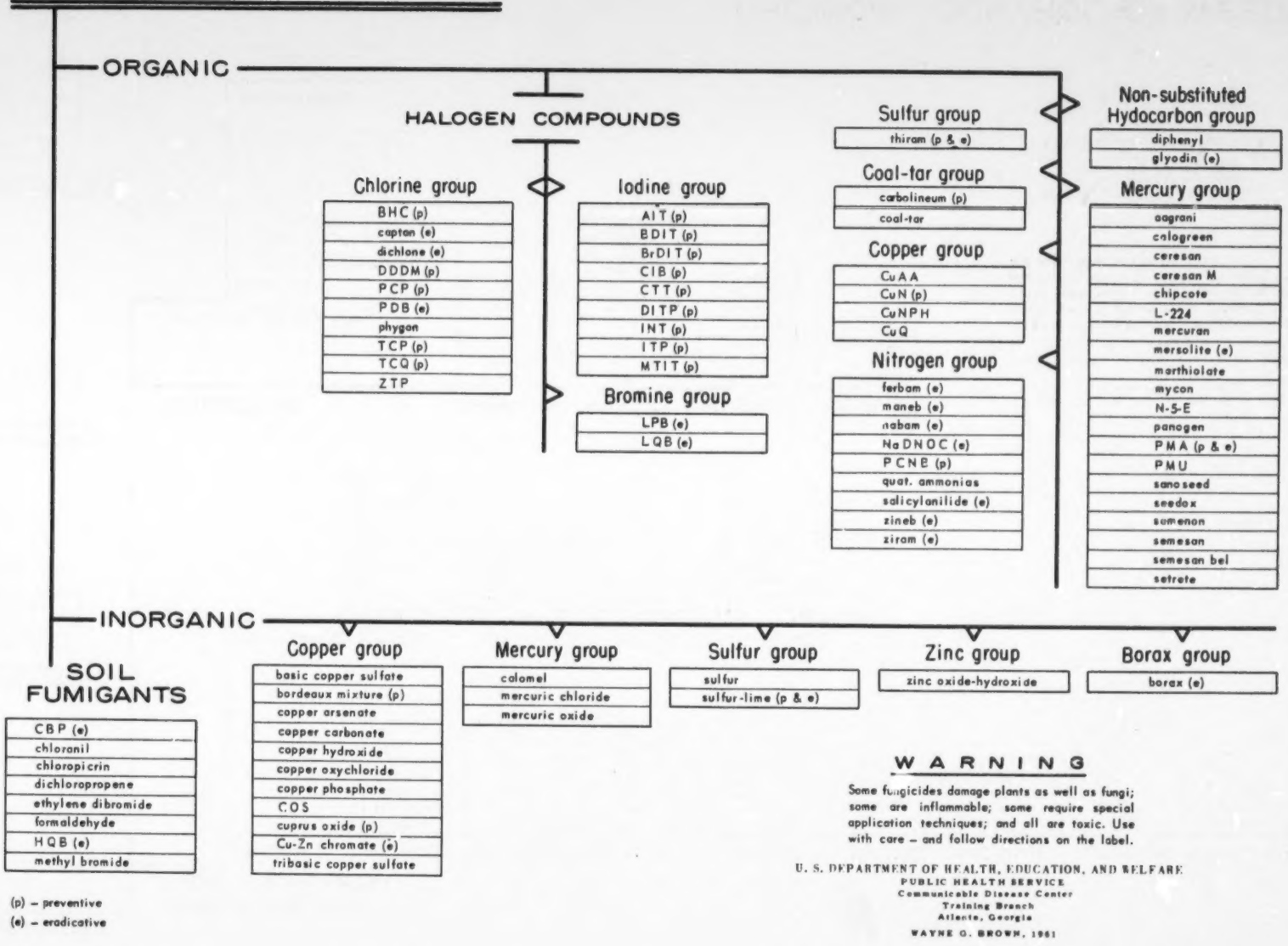
CHEMICAL CONTROL OF WEEDS

ECONOMIC FUNGICIDES



(p) – preventive
(e) – eradicative

WARNING

Some fungicides damage plants as well as fungi; some are inflammable; some require special application techniques; and all are toxic. Use with care – and follow directions on the label.

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PUBLIC HEALTH SERVICE
Communicable Disease Center
Training Branch
Atlanta, Georgia
WAYNE O. BROWN, 1961

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PESTICIDES in Your Future

by William M. Hoffman

Caught in the midst of an ecological controversy, the superintendent is rightfully concerned about the pesticides available to him; here's an insight into what the pesticide future holds for the superintendent.

There are only so many acres of land, so many cubic feet of air, so many gallons of water available on this earth. Man must, therefore, stop exploiting these resources and learn to manage them more efficiently if he is to survive.

The accelerated growth of science and applied technology has given us increased power and produced tremendous benefits to human life. However, we did not fully anticipate that the environmental modifications which accompanied our good intentions would have an impact on our health and welfare.

Now that we have come to the realization—almost in the eleventh hour—that our environment is endangered, we want to do all that should have been done earlier. This, despite the fact we have not been heeding the warnings of biologists, conservationists, ecologists and others aware of the approaching crisis.

DDT, one of the persistent chlorinated hydrocarbon insecticides, is a case in point. Although it was initially used mainly for disease vector control during and immediately after World War II, its production increased sharply with expanded use for control of a variety of pests on various agricultural crops. In 1962, Rachel Carson in her book *Silent Spring* alleged that DDT and its metabolites were highly injurious to some nontarget species and threatened other species and biological systems and further accentuated the pesticide controversy.

Pesticides—Pros and Cons

We, the public, have a right to be concerned over the effects of pesticide chemicals on the environment. Spokesmen on both sides of the controversy have exaggerated, on occasion, to attract interest.

There are those who insist that the food chain will be irreparably interrupted if pesticides are not outlawed. They also charge that various species of animal life are becoming extinct. And they forecast that if we survive the coming environmental disaster, our grandchildren may suffer innumerable

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In November 1972, William M. Hoffman became acting director of the Division of Technical Services, Environmental Protection Agency. This division includes the chemical and biological laboratories, the pesticides monitoring programs, the technical data and information retrieval units and the computer data systems.

birth defects caused by chemical pesticides.

On the other hand, the World Health Organization states that the poorer nations of the world would suffer most from hunger and disease if DDT were universally banned. According to the U.S. Department of Agriculture, our agricultural production would drop 30 per cent if all pesticides were banned. An industry source predicts that some 50 million Americans would starve to death if farm chemicals were withheld from agriculture.

These arguments and fears have led to actions by federal agencies, first the U.S. Department of Agriculture and now the Environmental Protection Agency, to review the uses of many of these chemicals. Suspensions and cancellations covering certain uses of aldrin, dieldrin and the herbicide 2,4,5-T are now final and all uses of DDT have been cancelled as of December 31, 1972. EPA is also carrying out intensive reviews of registrations of products such as benzene hexachloride, lindane, heptachlor, chlordane, endrin and toxaphene, as well as all products containing mercury, arsenic and lead.

Heavy Users of Pesticides

The golf course superintendent is caught in the midst of the pesticide controversy. Golf is the most popular participation sport in the United States today. There are more than 10,000 golf courses in the U.S., according to the National Golf Foundation, and an increase to 14.000 courses by 1980 is predicted. The Foundation also reports that the average 18-hole course covers some 140 acres while the average 9-hole course covers 60 acres.

The 1970 Harris, Kerr, Foster and Company "Statistical Review of Clubs in Town and Country" reported the average budget for an 18-hole course to be $88.632. Of this total, approximately $4,800 is allotted for fertilizers, $1,200 for herbicides, $1,800 for fungicides, and $570 for insecticides. Assuming the average course covers 100 acres, we can estimate that $20 million a year can be spent on pesticide products. Statistics such as these indicate that pesticides play an integral part in a superintendent's management tools.

Insecticides in the past have been applied four to five times over the season in the northern states and several more times in the southern states. These were mainly the chlorinated hydrocarbons since they were long-lasting and relatively inexpensive. Now that many of these chemicals are being removed from the available list, other means of control will be needed. At the present time, there appear to be available new chemicals with a shorter residual life, but they are more dangerous to use and more expensive than those which have been banned.

Lead arsenate, sometimes used in the control of *Poa annua*, crabgrass and certain insects, will probably be cancelled and so this chemical will also be lost to turf management. Very few other herbicides are applied to greens but large amounts of pre- and post-emergence compounds are used on the fairways. The broadleaved weeds, such as plantain, dandelion, chickweed, dock, etc., can usually be controlled with one treatment of 2,4-D, 2,4,5-TP, dicamba or MCPA. However, crabgrass and grassy weeds may require several treatments during the season to both the fairways and the tee areas. Even the roughs, which are usually the last to be considered in maintenance, are now sprayed for weeds.

The greatest amount of pesticide money is spent on fungicides. Today's greens average about 7,500 square feet and some are more than twice this size. Greens are the most expensive of all golf turf areas to maintain, as individual application costs vary from $0.10 to $4.00 per 1,000 square feet. Fungicides are usually applied weekly during the summer months and biweekly in cooler seasons and this practice can cover a six-month period or the entire year, depending on geographical location of the course.

The mercury-containing fungicides have been the chemicals of choice but now that all registrations of the alkyl mercury products registered for fungicidal use on ornamentals, turfgrass, trees and shrubs have been suspended, the newer systemics may have to take their place. The new fungicides are higher in price but they provide longer protection against disease and require fewer treatments. Today, fungicides are also used on the fairways of many courses, as many club members now want excellent fairway turf as well as beautiful greens.

Costlier Chemicals

More and more money will be spent for the newer chemicals that are replacing the conventional materials like the persistent insecticides, the mercurials and the arsenicals. Is it any wonder that today's golf course superintendent is in a dilemma?

Life in the ecology era is complex. The superintendent will have to decide whether he can spend a little more money for the newer chemicals or if he can live with some weeds in the fairway or some bare spots on his prize greens. Does the weekly use of even the newer chemicals present a health hazard to the applicator or to the golfer who plays immediately after the spraying?

Turf research is providing him with some of the answers. Each year more progress is made—chemical controls for weeds and diseases are tested, new grass varieties capable of withstanding heavy use are marketed, pesticide and fertilizer management practices updated, all in the interest of improved golf courses.

The loss of alkyl mercury products has spurred interest in the development of new control chemicals. At the Corvallis (Ore.) Agricultural Experiment Station, a new systemic fungicide obtained from Eli Lilly and Company eliminated flag smut and effected 97 per cent control of stripe smut in Merion bluegrass under greenhouse conditions. Tests are now planned to determine its value under field conditions. Turf disease research work conducted in Wisconsin during the winter of 1970-71 centered on 16 fungicides that may replace mercury fungicides for snow mold. The Pennwalt Corporation has an EPA experimental permit for Topsin, a broad-spectrum turfgrass fungicide imported from Japan for control of many diseases on greens, tees and fairways.

Promise in Research

Two new varieties of interest to the golf course superintendent have

just been released from Pennsylvania State University. Pennstar is a new bluegrass variety that is very promising for tee and fairway use. Among its characteristics are disease resistance, compatibility, and the ability to withstand low mowing and to compete under low fertilization. Pennfine is a perennial ryegrass that has good heat tolerance and disease resistance, especially to snow mold and leaf spot.

While much of the herbicide investigations involve the standard chemicals, there are others pursuing new ideas, new chemicals and new uses of available products. The University of Rhode Island has found bromoxynil to be less phytotoxic than 2,4-D or MCPA and to have the added advantage of reducing the weed canopy in a few days, which could improve seedling growth and make mowing easier. Experiments were conducted at the same university to determine if half-rates of preemergent herbicides in the second year would give satisfactory control of crabgrass.

Many of our state universities are deeply involved in research of interest to the superintendent and he might well visit their agricultural experiment stations and meet the researchers and the extension service personnel in order to learn about new findings he might use in his management operations.

The New FEPC Act

The golf course superintendent will soon begin to hear about the provisions of the new Federal Environmental Pesticide Control Act of 1972 signed by President Nixon on October 21, 1972. The new Act completely revises the Federal Insecticide, Fungicide and Rodenticide Act, which has been the basic authority for federal pesticide regulation since 1947.

The law prior to the new legislation prohibited interstate commerce or unregistered pesticides and permitted registration only when, if used as directed or in accordance with commonly recognized practice, the pesticide would not be injurious to man, vertebrate animals or desired vegetation. It did not prohibit the misuse of any registered pesticides nor did it regulate pesticides that moved only in intrastate commerce.

The new Act regulates the use of pesticides to protect us and our environment and extends federal registration to all pesticides including those distributed or used within a single state.

The major provisions of the new Act that will affect the golf course superintendent are as follows:

1. *The prohibition of the use of any pesticide inconsistent with its labeling.* No pesticide may be registered or sold unless its labeling is such as to prevent any injury to man or unreasonable adverse effects on the environment.

2. *The classification of all pesticides for either "general" use or "restricted" use.* A general use pesticide is one which, when applied in accordance with its directions for use and any warning or caution statements, will not cause substantial adverse effects on the environment, including any injury to man. A restricted use pesticide is one which could cause substantial adverse effects on the environment without additional regulatory restrictions. If its effects pose an immediate threat to human health or safety or environmental values, the Act provides that the restricted use pesticide must be applied by or under the direct supervision of a certified applicator either private or commercial. The certification will be accomplished by state programs whose plans are approved by EPA.

[Golf course superintendents should have no fear of these licensing procedures because the superintendent who has GCSAA certification has already shown that he is fully capable of handling and supervising the use of pesticides. One part of the six-part examination for GCSAA certification is devoted to pesticides. Therefore, the superintendent who passes the certification examination indicates to local, state or federal pest control licensing agencies that he is fully proficient and capable of handling and supervising the use of such materials—Editor.]

3. *The authorization of either civil or criminal penalties for any commercial applicator who violates the Act.*

4. *The payment of indemnitics to persons holding pesticides before the issuance of a suspension notice if the pesticide is finally cancelled.*

The future of the golf course superintendent is very bright and will continue to be bright. Golf courses enhance our urban and suburban areas as they are an integral part of the shrinking greenbelt around our cities. They affect our very lives by absorbing noise, serving as coolants (an acre of grass has the cooling effect of a 60-ton air conditioner), and removing chemical pollutants from the air. Let's not let the pesticide controversy lead to the loss of these integral parts of our environment. ■

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PUBLICATION 17

TOXICOLOGY PROGRAM
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Pesticide Toxicity Can Be and Is Being Avoided

PESTICIDES FORMULATION

Relation to Safety in Use

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In arriving at improved safety of formulations, substitution of less toxic active ingredients, and use of emetics, warning colors, and antidusting agents and compounds to retard absorption are important. Highly toxic compounds may be employed with markedly decreased hazard if prior consideration is given to the incorporation of safety factors into the formulation itself, in addition to precautions usually advised.

FACTORS IN PESTICIDAL FORMULATION which may lead to greater safety in their use are enumerated here, and certain examples are discussed. Very little has been written on this specific subject, although it is worthy of extensive consideration.

Increasing Safety of Formulations

The safety of formulations may be increased in a number of ways, but not all of them are applicable to any single situation. Some remarkable successes have been achieved in recent years in developing relatively harmless pesticides.

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Table I. Concentration of Parathion in Air during Mixing of Spray Solutions by Addition of Parathion Formulations to Water

(Micrograms per liter)

Ordinary WWP*		Antidusting WWP*	Liquid
3.95	2.43	0.17	0.06
3.24	0.27	None	Trace (0.03)
1.36	5.53	0.03	Trace (0.01)
0.28	0.69	None	Trace (0.02)
	2.58	1.62	
	1.02	0.12	None
	2.50	Trace (0.07)	None
		0.09	None
		0.53	Trace (0.16)
		None	
		Trace (0.12)	
		1.68	
Mean 2.21	2.15	0.37	0.04

* Water-wettable powder.

However, the fact that hazardous chemicals remain in use is proof that safer but equally effective materials are not available at an economical cost. A toxic insecticidal chemical remains a safety problem, no matter how formulated. This fact should not discourage efforts toward improved formulation, even though such efforts cannot replace a careful, adequate, and continuing educational program to ensure safe handling.

The use of inherently less toxic active ingredients is the most obvious improvement that can be made in the formulation of a pesticide, and frequently this is the only change mentioned in discussions involving safety. The most striking example in recent years is the substitution of DDT [2,2-bis(*p*-chlorophenyl)-1,1,1-trichloroethane] for lead arsenate. Instances of chronic lead poisoning associated with orchard spraying were reported in a paper so recent that it mentioned that the older material was then being replaced by DDT (*3*). Acute poisoning by lead arsenate and other arsenicals also was encountered. By contrast, there are no confirmed cases of chronic DDT poisoning; confirmed, uncomplicated cases of acute DDT poisoning are all associated with the accidental eating of a relatively large quantity of DDT, amounting in some instances to 20 grams of the technical material (*4*). The record of DDT has been so good that it has been necessary to emphasize at every turn that the compound is not harmless and should be used with appropriate precaution. It was not so necessary to emphasize the all too apparent dangers of the arsenicals.

Another striking example of the use of an inherently less toxic active ingredient is the substitution of warfarin [3-(α-phenyl-β-acetylethyl)-4-hydroxycoumarin] for a number of highly toxic, quick-acting rodenticides, including 1080 (sodium fluoroacetate). It has been clearly demonstrated that warfarin is at least equal, if not superior, to any of the old rodenticides from the standpoint of control. By contrast, it has an excellent safety record. It is true that ANTU (α-naphthylthiourea) has a good safety record, but it is useful only in a limited number of situations. Red squill has a good safety record, with only a few human fatalities ascribed to it; however, many have found it essentially useless as a rodenticide. There is still need for a highly efficient, safe, quick-acting rodenticide.

It may be that malathion [*S*-(1,2-dicarbethoxyethyl) *O,O*-dimethyl dithiophosphate], NPD (tetra-*n*-propyl dithionopyrophosphate), and some of the other new organic phosphorus insecticides which are less toxic to mammals will prove sufficiently effective to be substituted for parathion (*O,O*-diethyl *O*-*p*-nitrophenyl thiophosphate) and TEPP (tetraethyl pyrophosphate). Other examples could be added.

Development of Safe Formulations

Solvents In developing formulations with a maximum safety factor for any particular active ingredient, the solvent is certainly of great importance, for one or more solvents frequently constitute the bulk of liquid preparations.

Because DDT shows some chemical relationship to the common chlorinated hydrocarbon solvents, pharmacologists very early explored the possibility that its mode of action in mammals might be similar. Experience has shown that the action of DDT on the liver and kidney, the organs chiefly affected by the chlorinated hydrocarbon solvents, is of secondary importance. Even so, the suggestion that chlorinated solvents be avoided in formulating DDT (*5*) is still a good one.

The avoidance of solvents with a high inherent toxicity is, of course, indicated. Benzene may cause a severe depression of the bone marrow activity with consequent anemia, and should be avoided as a solvent for pesticides wherever possible.

Another danger inherent in many solvents is their flammability. In this regard, the chlorinated hydrocarbon solvents are relatively safe and this property must be kept in mind in evaluating their over-all safety applicability. The conditions of use must also be considered. Formulations that would be entirely too flammable for use in aircraft can be used safely in certain other situations.

Dusts Dusts serve as a vehicle or diluent in dry formulations and should be selected for nontoxicity just as liquid solvents are selected. In particular, this means holding the percentage of free silica to a minimum and avoiding the use of talc, one of the few silicates known to cause silicosis. There is little danger of silicosis to the person who uses dusts occasionally, but the exposure of the commercial applicator or mixing plant worker may be significant.

Over and above the threat of silicosis, all dusts are somewhat irritating to the respiratory tract. For this reason, and because of the toxicity of the active ingredient, the development of antidusting formulations is a marked improvement. Their use in water-wettable powders allows the worker who mixes suspensions in the field to encounter significantly smaller concentrations in the air. Table I shows the air concentration of parathion at the level of the worker's face during the mixing process in an apple orchard. During 1951 and 1952, the concentration of parathion averaged slightly over 2 micrograms per liter with ordinary wettable powder. In 1952, an average of 0.37 microgram per liter was found with an antidusting pow-

Table II. LD_{50} Values of Parathion Formulations Applied Dermally to Female White Rats

(Mg. per kg.)

Formulation	LD_{50}	19/20 Confidence Limits
Xylene solution of technical product	10.9	7.9–12.9
Aqueous suspension of plain water-wettable powder	15.0	10.1–22.4
Aqueous suspension of antidusting water-wettable powder	18.0	14.0–22.9

Table III. Mortality of White Rats Receiving Single Dose of Different 6.25% Dieldrin Formulations Dermally

(100 mg. of dieldrin per kilogram of body weight)

Formulation	Mortality	
	Fraction*	%
Liquid concentrate	9/9, 10/11	95
Paste-type concentrate	3/10	30
Mayonnaise-type concentrate	2/5, 0/5	20

* Ratio of number dead to total number treated.

Table IV. Mortality of White Rats Receiving Single Dose of Different 2.5% Parathion Formulations Dermally

(Each at rate of 40 mg. of parathion per kilogram of body weight. In each instance solvent was xylene)

Formulation	Mortality, Fraction[a]	Mortality, %
Parathion solution	10/10, 10/10	100
Parathion-DDT-rosin-Triton X-155[b] solution	1/10, 2/10	15
Parathion-rosin solution	5/10, 25/50	50
Parathion-DDT solution	3/10, 43/50	77
Parathion–Triton X-155[b] soln.	9/10	90

[a] Ratio of number dead to number treated.

[b] Emulsifier made by Rohm & Haas Co., Philadelphia, Pa.

der, and the highest value found (1.68 micrograms per liter) was smaller than the mean for the unimproved formulation.

It will be noted in Table I that the average concentration of parathion in the air associated with the mixing of sprays from liquid concentrates was less than 0.04 microgram per liter.

This almost certainly indicates that liquid concentrates offer less hazard so far as respiratory exposure is concerned. Considerations of this kind have led to the adoption of liquid concentrates in England and in Germany (*1*). In this country, it has been thought that the advantage of liquid formulations in regard to respiratory exposure will be overbalanced by their supposed greater hazard in regard to skin exposure. Actually, the dermal toxicity of xylene solutions of parathion is only slightly greater than the toxicity of water-wettable powders, as shown in Table II. It is argued, however, that the hazard of powders is less because they are less likely than liquids to adhere to the skin. The conditions of use in England and in the United States are not sufficiently similar to permit a comparison. It must be recorded, however, that no fatal accidents with parathion have been reported from England. The possibility that liquid formulations may have more over-all safety than any kind of dust or powder formulation of the same concentration is worth considering. This is true not only of concentrates, but also of formulations ready for use, including those dispersed by aircraft.

Granular preparations of insecticides have been used for the control of malaria mosquito larvae or soil insects, where the cover is too dense to permit direct treatment of the water or soil. The granules reach places that sprays or ordinary dusts cannot penetrate, and also reduce somewhat the hazard of respiratory exposure.

Pastes. Among the solutions and emulsions, some formulations have been prepared to reduce absorption either by reducing the possibility of contamination or in some more subtle fashion. For example, as shown in Table III, paste- and mayonnaise-type emulsion concentrates of dieldrin (1, 2, 3, 4, 10, 10-hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4, 5, 8-dimethanonaphthalene) were less toxic than ordinary concentrates of the same strength. This was true even though in the experimental procedure the thick materials were rather laboriously rubbed into the skin at the prescribed dosage. Actually, the safety factor is much greater than the figures indicate because, if contamination does occur with the paste- or mayonnaise-type preparations, the material does not spread on the skin but tends to stand up in a mound. Unlike a liquid preparation, most of it can be quickly wiped from the skin without the use of soap and water.

In connection with the organic phosphorus insecticides, some progress has been made in developing formulations from which mammals absorb the active ingredient less readily. In an effort to get a longer residual action and in the hope of finding some synergistic action against resistant houseflies, parathion was formulated with DDT and rosin. The effectiveness of the combination as a residual, when tested in the laboratory against DDT-resistant houseflies, was found greatly superior to equivalent dosages of DDT or parathion alone. On the contrary, white rats received marked protection from the parathion in the combination. Results are shown in Table IV. The dosage of parathion was identical in each instance.

The use of special emulsifiers to increase the safety of Systox (diethoxythiophosphoric ester of 2-ethylmercaptoethanol) formulations has been reported (*2*).

Protective Measures

Protective skin coatings do not involve pesticide formulations directly, but it may be possible to develop skin treatments which would partially protect workers from dermal exposure to certain chemicals. Theoretically, this protection could operate through chemical inactivation of the toxin or through preventing its absorption. It is, of course, of the greatest importance that skin treatments be rigidly tested before any confidence is placed in them—for example, a commercial, "oil-resistant" cream gave no protection whatever against the subsequent dermal application of dieldrin emulsions.

The use of emetics and the coloring of formulations are well-known ways of making preparations safer, but the usefulness of these methods is limited. Emetics have been used with rodenticides with some success. Antimony potassium tartrate is commonly combined with zinc phosphide, thallium sulfate, and arsenic trioxide. Combination of the tartrate with ANTU is unnecessary because of its low toxicity to humans and combination with 1080 is useless, because the latter poison acts too rapidly. Red squill has an inherent emetic property, and it is thought that this is a property of the toxic glycoside itself and not of contaminants. Unfortunately, the acceptability to rats of red squill and of other emetic rodenticide formulations is poor.

Color has been used to make rodenticidal formulations completely distinct from desirable food or potable water. Compound 1080 is now used only with the addition of nigrosine black.

Discussion

The introduction of the new synthetic organic compounds has permitted a marked increase in the use of pesticides, not only in agriculture but also in public health. Partly because of the cost factor but chiefly because of increased effectiveness, pesticides are now being used in many situations in which they have never been used before. Even for many old established uses, the tonnage of economic poisons employed annually is now greater than ever before. The very magnitude of the quantities used would seem to require more attention to the safety factor.

This question of safety, involving toxicity to plants, to useful animals, and to man, has an important bearing on any future increase in the use of pesticides. The literature on the phytotoxicity of pesticides and on ways of reducing phytotoxic effects by various formulating methods is rather voluminous, especially in the case of arsenical insecticides and copper-bearing fungicides. This work related to plants illustrates that real progress toward safer formulations can be made. More important, it is entirely possible that a review of the methods used in improving the safety of formulations for plants would indicate that these same methods could be applied in improving the safety of formulations to man and domestic animals.

The very limited data submitted here suggest that highly toxic compounds may be employed with markedly less hazard if prior consideration is given to the incorporation of safety factors into the formulation itself in addition to the precautions usually advised in its use. It is even within the realm of possibility that some of the fatalities which have occurred with parathion might have been avoided with safer types of formulations. The mortality experience with parathion seems to have stimulated a search for less acutely toxic materials, especially among the organic phosphorus compounds. Although this substitution is a desirable approach, one should not overlook the possibility that highly toxic compounds may be practical, especially

if they lend themselves to increased safety through improved formulation. In fact, in some cases the substitution of a highly poisonous compound with no cumulative effect for a material having less acute but more residual toxicity may be desirable. The hazard in the use of the former type of compound on food products involves only the spray workers, while the latter potentially involves the whole population.

Irrespective of the type of toxic ingredient employed, the desirability of using improved formulations or other safety devices which tend to reduce intake through the skin, the respiratory system, or the digestive tract should be emphasized to all those connected with the pesticides industry.

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PESTICIDES AND THE FOOD SUPPLY

PUBLICATION 187

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SUMMARY

The use of chemical pest control agents undoubtedly constitutes a calculated risk; nonetheless, the proper use of these agents results in benefits which, at the present time, far outweigh the known potential hazards. Considerable care must be exercised in the selection, storage, and use of pesticide chemicals and in the disposition of the empty containers. Since virtually all pesticides are more or less toxic to man and cumulative and potentiation characteristics are not well defined, regulation through registration and the establishment of residue tolerances is essential. Scientists recognize that the adequate production and preservation of food and fiber and the protection of human health require the use of chemical pesticides. Federal, state, and local health agencies and the food and chemical industries are striving through research and residue surveillance to show the effect of pesticides on human beings and to provide alternative means of pest control. Until these chemical agents are replaced by less toxic means of control, the use of pesticides will continue. As in any scientific venture, the benefit-hazard ratio in the use of pesticides may never be completely established, but we must act on the best available evidence.

The production of an abundance of high-quality nutritious food for mankind has always had its share of problems. For many years, these were essentially microbiological in nature and were concerned with production and processing sanitation to prevent spoilage and foodborne illness. Recently, however, the increased use of chemicals in agricultural practices has resulted in a new problem—residues in food.

The publication *Silent Spring (9)* focused attention on pesticides—their beneficial and harmful characteristics; their effects on the balance-of-nature, the fish and wildlife population, the food supply, and domestic animals; and their total impact on man. Many questions were posed, but they could not be answered with any degree of accuracy. Consequently, to the concerned and confused public, the problems associated with pesticides became as important as those of antibiotic residues in milk, radionuclides in food, the relationship of animal fat to cholesterol level in man, and community air and water pollution.

Although recent papers in the scientific literature have called attention to the general environmental problems associated with pesticides *(10 36, 56)*, a review of the food phase of the problem is appropriate *(8)* since about 90% of mans' pesticide intake is through the food chain.

CLASSIFICATION OF PESTICIDES

Pesticides may be classified in terms of use and as chemical compounds. Pesticides used to control insects are referred to as insecticides; similarly, rodenticides are used to control rats, mice, and other rodents; herbicides, to destroy unwanted vegetation; soil sterilants, to destroy undesirable plant seed and insect life in the soil; fungicides to prevent and control plant diseases; and fumigants to prevent and control insect and like infestations in stored grain.

Pesticides are chemically classified as chlorinated hydrocarbons, organic phosphates, carbamates, miscellaneous organics, and inorganic compounds. These classifications often signify little in terms of use since a compound may be employed to control several kinds of pests. Literature is available on the chemical composition and classification of pesticides both from manufacturers' and government agencies *(23, 42, 81)*.

SALE AND USE OF PESTICIDES

By 1964, more than 60,000 formulations, representing approximately 900 chemical agents, had been registered for use in the United States, and the estimated sales of synthetic organic pesticides by primary producers amounted to about $426 million *(75)*.

Actual figures are not available for other pesticides, but the total supply is estimated at about $500 million with a gross weight of about 1 billion pounds *(75)*. DDT was the most commonly used pesticide and accounted for 12.4% of the total production.

REGULATION AND CONTROL OF PESTICIDES

The United States Department of Agriculture (USDA) is responsible for the control of pesticides under the authority of the Federal Insecticide, Fungicide, and Rodenticide Act. The Food, Drug, and Cosmetic Act assigned the responsibility for safety of foods to the Department of Health, Education, and Welfare (DHEW) and the Secretary thereof delegated this responsibility to the Food and Drug

[1]Present address: Bureau of State Services, Environmental Health, Public Health Service, Washington, D. C.

Administration (FDA). An interdepartmental agreement was formalized in April by the USDA, Department of Interior (DI), and DHEW to coordinate their activities relating to the registration of pesticides and the establishment of tolerances *(22)*. Although the USDA retains administrative responsibility for the Federal registration of pesticides, the FDA and the Public Health Service (PHS), of the DHEW, and the DI are charged with joint responsibility for the review of applications for pesticide registration with regard to their safety for man, fish, and wildlife, prior to registration by the USDA.

To be sold in interstate commerce, a pesticide must be registered with the USDA. In applying for registration, the manufacturer must submit information about the product as to intended use, efficiency of use, directions for use, chemical composition, and toxicological data *(77)*. If, on the basis of data submitted, the USDA finds that no residue remains on food, the pesticide will be registered on a "no residue" basis. If the pesticide does leave a residue and is proposed for use on food crops and animals, the manufacturer must file a petition for tolerance with the FDA, in addition to the application for registration with USDA. This petition must present additional data on toxicity, the tolerance requested, evidence that proper use of the pesticide will not leave a residue in excess of the tolerance, and description of an analytical method for detecting the pesticide at the tolerance level. The FDA can then establish a tolerance on crops or animals as petitioned, whereupon the USDA will grant registration of the pesticide. Registration of the pesticide and establishment of tolerances do not preclude future review and change *(77)*. Each registration must be renewed exery 5 years. Official FDA tolerances for raw agricultural products are published annually *(58)*.

Tolerance levels are normally set at 1/100 of the amount found to produce toxicity symptoms in experimental animals, but never higher than necessary to accomplish pest control according to the recommended use of the pesticide. If a compound is found too toxic to permit a residue, the FDA will establish a "zero tolerance" *(77)*. Both "no residue" and "zero tolerance" are modified as analytical methods become more sensitive *(77)*. One example of this is the "zero tolerance" in milk. For practical purposes FDA had previously considered the "effective zero", or actionable level, to be 0.1 ppm of DDT in whole milk, simply because 0.1 ppm was the lower limit of detection of the official method of analysis *(1)*. More recently FDA has stated that in the future any milk containing 0.05 ppm, or above, of DDT, or 0.01 ppm, or above, of any one of a number of other chlorinated hydrocarbons, such as dieldrin and endrin, would be subject to seizure *(16)*.

Because of its unique position in the feeding of infants, the elderly, and the sick, milk is not considered in the broad category of raw agricultural products. While tolerances as high as 10 ppm have been set for many pesticide residues on various fruits and vegetables, milk and its products are currently required to have a zero pesticide residue concentration. Considerable controversy has occurred as a result of the zero requirement for milk. The Food and Nutrition Board of the National Academy of Sciences (NAS) has recommended that a reasonable tolerance for pesticides be considered in milk *(77)*, and the FDA has stated that they will consider petitions to set tangible tolerance levels in milk for any pest control agent *(46)*.

Recently the "no residue" and "zero tolerance" concepts have been studied by a committee sponsored by the NAS. Although no immediate changes are anticipated, this committee has recommended changes in the basic considerations in the registration and regulation of pesticide chemicals. The most pertinent ot these changes involves the abandonment of "no residue" and "zero tolerance" in favor of the more readily definable terms, "negligible" and "permissible" residue levels *(63)*.

NECESSITY FOR CONTROL

The mere fact that food and drug laws treat pesticide residues as food adulterants is reason enough to consider such products objectionable. Pesticides, moreover, are not only necessarily toxic to the pests they are intended to control, but many of these agents are also toxic to man and warm-blooded animals. The toxicities of the various pesticides have been studied extensively *(2-5, 13, 30, 33, 35, 62, 82)* Admittedly, these compounds are quite toxic at high concentration or dosage levels. Some examples of accidental or intentional misuse of pesticides causing illness or death as reported in the literature are the accidental ingestion of relatively large quantities of pesticides by children, excessive exposure of applicators to dusts and sprays through both ingestion and absorption, careless handling of pesticides, thoughtless disposal of the so-called "empty" containers, and intentional poisonings or suicides *(14, 24, 25, 32, 38, 41, 55, 57, 67, 85)*. In the absence of long-term toxicity studies, it cannot definitely be said that the minute residues normally found in contaminated food, are harmful to man. Actually there is evidence to the contrary *(34, 87)*. However, of most concern is the less obvious, more subtle and potentially cumulative effect of low-level, long-term exposure of man to the various pesticide chemicals, individually and collectively *(20, 66)*. These effects

assume a status of more importance when certain characteristics of chemical pesticides are considered.

Chlorinated hydrocarbons are fat-soluble, and most of them tend to accumulate in the fatty tissue of man and animal. The extent of such accumulation and the danger therefrom over a long period of time is not known. DDT and perhaps many other pesticides are rather universally distributed in nature as evidenced by their presence even where applications have probably not been made *(70)*. DDT and DDE concentrations in human body fat in Canada have been estimated to be 3.1 to 7.6 and 7.7 to 20.4 ppm, respectively *(64)*. Estimated DDT in the body fat of the general population in the United States averages about 12.0 ppm, while that of residents of England and Germany is considerably lower *(77)*. These data may reflect—differences in food consumption habits in these countries, since it has been shown that in the United States abstainers from meat retain about half as much DDT as that retained in the general population *(34)*. More recent data, accumulated from a somewhat larger population, indicate a slightly lower DDT concentration in human body fat in this country *(37)*. DDT once stored in the body fat is metabolized and released very slowly, as shown by Huddleston, et al. *(39)*. These investigators found that dairy animals feeding on pasture that had been given a single application of 2 pounds of DDT spray per acre initially secreted milk containing 3.77 ppm and, at the end of 1 year, produced milk containing 0.53 ppm *(39)*. These data have been validated for both milk and meat by Kartashova *(43)* and Gannon, et al. *(26)*. Recent studies indicate that other chlorinated hydrocarbon insecticides are metabolized in a similar manner *(29)*.

Organic phosphate and carbamate pesticides are generally metabolized by both man and animal into compounds that are currently believed to be relatively nontoxic. Although none of the organic phosphate pesticides appear to remain as such in man or animal for any appreciable period of time, absorption of these agents is probably more hazardous than ingestion. Studies indicate that the poisoning of pesticide applicators by organic phosphates is usually through adsorption *(31)*. Residues of certain of these agents have been found in milk as a result of ingestion by the animals; however, more persistent residues in higher concentrations have been found to result from dusting and spraying of animals *(11, 61, 65)*.

Certain combinations of organic phosphate insecticides have exhibited the characteristic of potentiation or synergistic action *(60)*. This phenomenon results in a much more pronounced effect than could be explained by the additive effects of the two or more individual agents. Potentiation has been reported to result from interference by one of the agents involved with the normal metabolism and detoxification of the other compound or compounds *(17)*. Thus, intoxicating activities of the additional compound or compounds are allowed to proceed more or less uninhibited. Synergistic action may occur among other chemical species of pesticides or perhaps between pesticidal agents and other environmental chemicals, as indicated by observations with carbamate insecticides and organic thiocyanates *(18)*. Consequently, although the consumption by human beings of drugs and other chemical entities together with pesticide residues in food may not be cause for great concern, such relationships are certainly a fertile area for concentrated investigation.

Whether or not synergistic action occurs among chlorinated hydrocarbon pesticides has not yet been established. Early investigations by insect bioassays of combinations of these agents produced conflicting data *(77)*. Recently it has been shown that the concentration of dieldrin in rat tissue decreased in direct proportion to the amount of DDT contained in the DDT-dieldrin supplement fed to the rats *(69)*. Such data may suggest an antagonistic action between these agents.

Decomposition of pesticides by the metabolic activities of man and animal might be responsible for a portion of the acute toxicity and the more subtle potential effect. The intermediate and end products of all pesticidal agents are not known. Many of these may exhibit an acute toxicity which is equal to or greater than the parent compound, as in the case of heptachlor epoxide, produced by the metabolism of heptachlor *(68, 88)*. On the other hand, DDT is metabolized to the nontoxic entity, DDE *(45)*. Metabolic modification of pesticides is not limited to animal and man. Lichtenstein and Schultz *(50, 54)* contend that plants also convert certain of the insecticides to their corresponding epoxides. Soil conditions, sunlight, air, and rain are also responsible for the decomposition of pesticides into new compounds that are often as toxic as their parents *(51-54)*.

Heptachlor epoxide, dieldrin, and endrin exemplify still another potential danger, carcinogenicity, since they contain an epoxide grouping in their molecule and certain other compounds having the epoxide structure have already been shown to be carcinogens *(47)*. Recent investigations of a number of epoxides indicate however, that only certain species of diepoxides are carcinogenic *(83)*. None of the monoepoxides tested (presumably those compounds more closely related to heptachlor epoxide, dieldrin, and endrin) were found to produce carcinoma in rats. The investigators caution, however, that this work is only preliminary and further study is needed.

Since neither heptachlor epoxide, dieldrin, nor endrin were included in the study, it would be unwise to conclude at this time that these insecticides are not carcinogenic. Recent reviews on insecticides as potential carcinogens have been prepared by Durham and others *(17, 21, 59)*.

Investigators, in their assessment of the biological problems in wildlife, have raised the question of sublethal effects of residual insecticides and have presented some evidence with respect to the subtle activities of such agents. Evaluation of the detrimental effect of pesticides on wildlife has been previously concerned with mortality, or the determination of the numbers and percentages of fish, birds, or mammals that died following the application of a toxicant. However, of equal concern is the morbidity the animals suffer. What effects these toxic agents have on growth, reproduction, mutagenesis, or other biological processes are not fully determined. In chronic toxicity studies with quail and pheasant fed 0.14 mg of certain chlorinated hydrocarbon insecticides daily for 2 months, Dewitt has shown that eggs of reduced hatchability were produced and the resulting chicks were subject to high death rates *(15)*. Additional evidence indicates that pesticide residues do cause genetic changes *(7, 12, 73)*.

How Food Is Contaminated

Food products undoubtedly contain some pesticide residues *(77)*. These contaminants enter the food supply in a number of ways. Crops may be contaminated by direct application, by uptake from the soil and water, or by accidental means such as fallout or drift from applications to adjacent fields. Lichtenstein, et al. *(50, 54)* have shown that translocation of pesticides from soil to plants does occur and that certain vegetables tend to concentrate the agents. Evidence also indicates that many of the chlorinated hydrocarbons persist for long periods of time in soil and plant debris *(86)*. Residue concentrations in cereal grains are at times increased by fumigation of storage bins and containers.

Residues in milk and meat may result from direct application to the animal or from the animal's ingestion of residue in feed and water, inhalation of the toxic vapors, and, to some extent, absorption, inhalation, and ingestion from applications to the animal's housing. Waste disposal, runoff from agricultural areas, and direct application of pesticides to water for the control of undesirable aquatic vegetation and marine life often result in the contamination of fish and shellfish *(19)*.

All foods may inadvertently be contaminated during production, in the processing plants, and in the home. Consequently, all food materials provide a continuous, though extremely limited, source of these potentially hazardous agents.

Efforts to Safeguard Food

In July 1964, the Federal Committee on Pest Control (FCPC), was established by the Secretaries of USDA, Department of Defense, DI, and DHEW consisting of two members and two alternates from each of the four Departments to coordinate interdepartmental efforts in accordance with the recommendations of the President's Science Advisory Committee in its report "Use of Pesticides" *(77)*. The FCPC provides a continuous review of all direct uses of pesticides by the Federal Government and insures that the Federal programs will be conducted with maximum safety, effectiveness, and economy. Following review, FCPC recommends procedures to achieve the desired results while preventing or minimizing undesirable effects. The Committee recognizes the statutory duties of each Department, and its recommendations are not intended to limit statutory responsibilities. In addition, the Committee's responsibilities extend to pest control programs in which the Federal Government participates through planning, development, supervision, or financing. Furthermore, it coordinates government information, monitoring, and research on pesticides through special subcommittees.

In its initial program of development and evaluation of pest control agents, the USDA realized very early the possibility of harm from residues in food. Consequently, around 1940 this agency began to evaluate the hazards involved *(72)*. USDA studies, including feeding experiments, have contributed valuable information regarding recommended uses, amounts and frequencies of application, and persistency of residues on crops and in meat and milk. Perhaps the most valuable general service provided by this department is the publication annually of recommended uses and the amount and frequency of application of various pest control agents *(74)*.

The USDA is frequently called upon to apply pest control in the field. All of the large eradication and control programs, such as gypsy moth and Japanese beetle, are the responsibility of this department. Quarantine and control designed to reduce the number of pests, and thus decrease chemical pesticide applications, are additional functions. More recently, USDA scientists have been successful in the limited development of alternative pest control procedures, such as radiation sterilization of male insects and the use of sex attractants *(73)*.

The PHS is directly responsible for protecting the public health from hazards of pesticide use. Since 1940, human and animal experiments have been car-

ried out to determine the effect of pesticides on physiological functions *(76)*. In its program the PHS has investigated the uptake, retention, and excretion of chlorinated hydrocarbons, including buildup in body fat; the effect on the organism of residues as shown through short-term feeding trials; and the overall toxicity effect of many pest control agents *(30, 71, 77)*. Methods have been deveolped to detect toxic residues in air, water, milk, other food, and body tissue. Valuable data have resulted from surveillance of the environment, studies of the exposure of pesticide applicators and workers in chemical plants, and epidemiological investigations of pesticide incidents in homes, factories, and communities *(47)*.

The last and perhaps the most important phase of the work of the PHS is communication. All of the information that can be collected from PHS research and the work of others is made available to state and local health personnel and representatives of universities and industry by means of short courses, consulting services, bulletins, and training in analytical procedures and techniques *(79, 81)*.

Many of the analytical methods used today were developed by the FDA. It has established more than 2,400 separate tolerances for over 125 chemicals and has maintained a constant survelliance of food in interstate commerce to enforce the existing tolerance regulations *(76)*. For example, in 1962 more than 25,000 food samples were analyzed *(46)*. Obviously not all contaminated food can be detected and removed from human consumption, but as the result of the efforts of this agency, the incidence of illegal pesticides in food and the average concentrations of residues in contaminated samples are on the decline *(44)*. Food producers and processors are apparently becoming more conscious of the potential hazards of pesticide residues in food and are making every effort to minimize such contamination.

The DI has the responsibility of protecting the natural outdoor environment from large accumulations of pesticides. Department scientists are seeking to learn more about the effect of pesticides on fish, birds, and other wildlife and to reduce the hazard in this portion of the human food chain. Considerable research is in progress toward the development of alternative pest control agents, both insecticides and herbicides *(22)*.

Not all work concerned with pesticides is being done by the Federal Government; agricultural experiment stations, universities, many state and local health departments, and state departments of agriculture are involved in research, surveillance, training, and regulatory activities. Although much of this work is being supported by Federal funds, the states themselves are spending large sums of their own money in support of these programs.

This discussion would not be complete without including the contributions of industry. The tremendous amount of developmental work by the pesticide manufacturer is responsible for many of the efficient pesticide agents and must be recognized. It has been estimated that the manufacturer spends an average of 5 years and $2 million in the development of a single pesticide and reportedly is able to put only 1 of 30 on the market *(27)*. Industry is constantly striving to improve these materials, to perfect relatively safe replacements for the more potentially hazardous agents, and to develop methods of analysis. It spends an estimated 1.7% of sales receipts to investigate potential health hazards of new products before these products are offered to the public *(6)*.

ANALYTICAL METHODS

The ultimate control of pesticide residues in food depends upon the development of an efficient surveillance prorgam. The major concern in such a program is the analytical methods used to detect and measure pesticide residues. Analysis of food for pesticide residues is fraught with difficulties. As indicated previously, 60,000 formulations representing more than 900 chemical agents were registered for use as of 1964. These formulations represent all of the chemical species previously listed. Residues must be detected and measured in concentrations of 10 to 0.01 ppm. Food products are of a complex chemical nature, usually difficult to sample, often requiring preservation, and generally difficult to prepare for analysis without loss or destruction of the agent in question. Consequently, the ideal analytical method for an efficient surveillance program would be a rapid screening procedure capable of yielding sensitivity in the area of 0.01 ppm of any of the potential pesticide residues, regardless of chemical species, from a crude extract of the food in question. Obviously such a method does not exist. Methods of analysis available today are long and laborious; are useful for a single pesticide, small groups of pesticides, or a single chemical species; are not completely specific; lack required sensitivity; or require expensive instrumentation and intelligent and well trained operators. Undoubtedly, the time required for analysis is the greatest problem in devising a realistic sampling system and thus an efficient surveillance program. Methods of analysis available consist of chemical colorimetric and titrametric procedures; biological assay methods; gas, paper, and thin-layer chromatography; and combinations of gas chromatography and spectroscopy or electrometric titration *(28)*.

PREVENTING CONTAMINATION

The utilization of analytic methods on food materials is for the most part an after-the-fact control procedure. While it has been reported that techniques exist for the removal of pesticide contamination from processed food materials *(40)*, investigation has shown that normal procedures followed in the manufacture of milk products are virtually ineffective in removing pesticide residues *(48, 49)* Consequently, the aim of food producers and processors is to supply food products as low in pesticide residue concentration as possible. A number of publications on the safe handling and use of pesticides are available *(76-78, 80, 81, 84)*. In general, pesticide contamination of food can be minimized by following the recommendations of Federal and state regulatory agencies, observing the manufacturer's instructions on the label, guarding against careless application, and carefully selecting animal feed materials.

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The Price for Pesticide Safety: *Constant Vigilance*

by ELDON P. SAVAGE and SAMUEL W. SIMMONS*

THE number of pesticides, total tonnage, and range of their use has continued to increase in the United States since 1945. Today there are more than 60,000 formulations of pesticides incorporating 500-600 pesticidal chemicals on the market.[1] The hazards of accidental poisoning increase concurrently with the increased usage. However, with few exceptions the safety record of pesticides in the United States continues to be good.[2]

Safe use of pesticides requires constant vigilance by everyone involved in the manufacture, transportation, storage, use and finally disposal of pesticide waste materials, because human error or carelessness in any step in the chain of events can result in a pesticide poisoning to man and animals.

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The present day pesticide safety record can be improved on through education and by learning more about the detailed epidemiology of pesticide accidents. Improvement in safety must be based on knowledge to be valid, and this knowledge, in turn, can be used to educate the public in the procedures to follow to assure safe use of pesticides.

Although poisoning by pesticides might be expected in occupational situations where the worker has long exposure to highly toxic material, the number of accidents involving such professional workers in the manufacture and use of pesticides is quite low. This is a reflection of good health programs and industry's ability to keep the worker informed of the potential hazard of materials and also strict adherence to use of safety devices in the work environment.

The marginal formulation plant and marginal pest control operation may provide the necessary conditions for pesticide poisonings. The small formulating plant may not have protective warning equipment, adequate exhaust systems, and personnel protective devices. Another common problem in this type of situation may be the lack of knowledge of prevention and treatment of pesticide poisonings by both management and the part-time plant physicians.

The marginal PCO may experience a similar type of problem. He frequently does not have the necessary funds for safety and precautionary equipment to help prevent pesticide accidents. As a result he and his helpers may be more apt to be victims of poisoning by pesticides than their counterparts in the larger, well-established pest control operations.

Pesticides enter the human body through oral ingestion, respiratory and dermal exposure.[3]

Illness From Exposure

The size of the dosage and the duration of exposure are of utmost importance in determining the degree of the ill effect of any pesticide on human health. Depending on the intensity and duration of dosage, illness may follow a single exposure or many exposures. Whether the illness is mild or severe will depend primarily on the amount of poison absorbed. Whether the illness is acute or chronic will depend mostly on the kind of chemical.

Safety Procedures

Management, operations personnel, physicians, nurses, and sanitarians who have direct contact with pesticides should do their utmost to keep abreast of the health and safety aspects of the pesticides they encounter. They should keep informed about the effectiveness of the chemicals used as well as the potential health hazards involved in the use of these materials. Specific recommended precautionary procedures include keeping your physician informed regarding the types of compounds used. Each potential victim of any accident should carry on his person records indicating blood type, history of transfusion reaction, significant history of diseases such as diabetes, or epilepsy, asthma and other allergies including history of drug sensitivities, and the name of any drug which is taken regularly.[4]

Employers should keep duplicate copies of these records on file in case the employee loses his copy. Employers should also maintain records on pesticides used, formulated and applied—as this information is often useful in obtaining complete medical histories in case of poisonings.

In some instances, workers in high exposure areas should obtain periodic physical examinations including the measurement of blood cholinesterase levels to indicate the amount of absorption of organic phosphorous insecticides.

Wearing of protective clothing and respirators is of utmost importance in protecting the worker in areas of high exposure or when loading or mixing wettable powders or applying dusts. Respirator filters and pads should be changed regularly.[5] Masks and respirators must be chosen for each compound. Objections to wearing or tolerating protective devices may be given by workers. However, experience has shown that when the wearing of protective clothing, gloves or respirators is explained to pesticide workers and the wearers understand the reason for wearing them—then they will usually wear the clothing that offers the most protection. Additional protection can often be realized by limiting the number of daily work hours and through good personal hygiene.[6]

Personal Hygiene

If hands are contaminated by

a pesticide or if contaminated objects are placed in the mouth, oral exposure may occur during eating, drinking or smoking. Therefore, everyone who handles pesticides should refrain from these activities until after they wash their hands. All pesticide workers should, of course, bathe and wear clean clothing daily. Strict attention should also be given to wearing freshly laundered headgear.

Transportation

Contamination of foodstuffs and other materials with pesticides during transport have been the cause of the largest number of deaths and accidents during 1967 associated with pesticides.

Results of contamination episodes during transportation of pesticides suggests that immediate consideration needs to be given to several aspects of pesticide transportation. One consideration is the possibility of shipping chemicals and foodstuffs in separate vehicles whenever possible. Another is to update and to keep the official posted list of dangerous materials for shipping up-to-date. For instance, neither parathion nor endrin are now on the official listing for loading ships in most countries, however parathion is on the United Kingdom list. A third consideration is the use of unbreakable containers for all pesticides.

Another important question is the safety procedures to pursue following highway accidents involving vehicles transporting pesticides. For example, in California recently a trailer loaded with parathion overturned and the liquid spilled onto the highway. The section of the highway was closed. The exact procedures to follow in this type of accident were not immediately available. Unfortunately, many of the basic answers to this type of problem are not known. However, meetings have recently been held to develop plans to take care of this type of emergency operation and research on detoxifying and neutralizing agents is also being increased. Some of the manufacturers of pesticides may also have information available on procedures to follow in case of spillage accidents. Hopefully, the answers to many of these types of problems will be available in the near future.

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Safety Considerations For Pesticide Handling

General

1. Use only when and where needed.
2. Keep only in labeled containers.
3. Store under lock and key.
4. Keep informed about pesticide safety.

Before Application

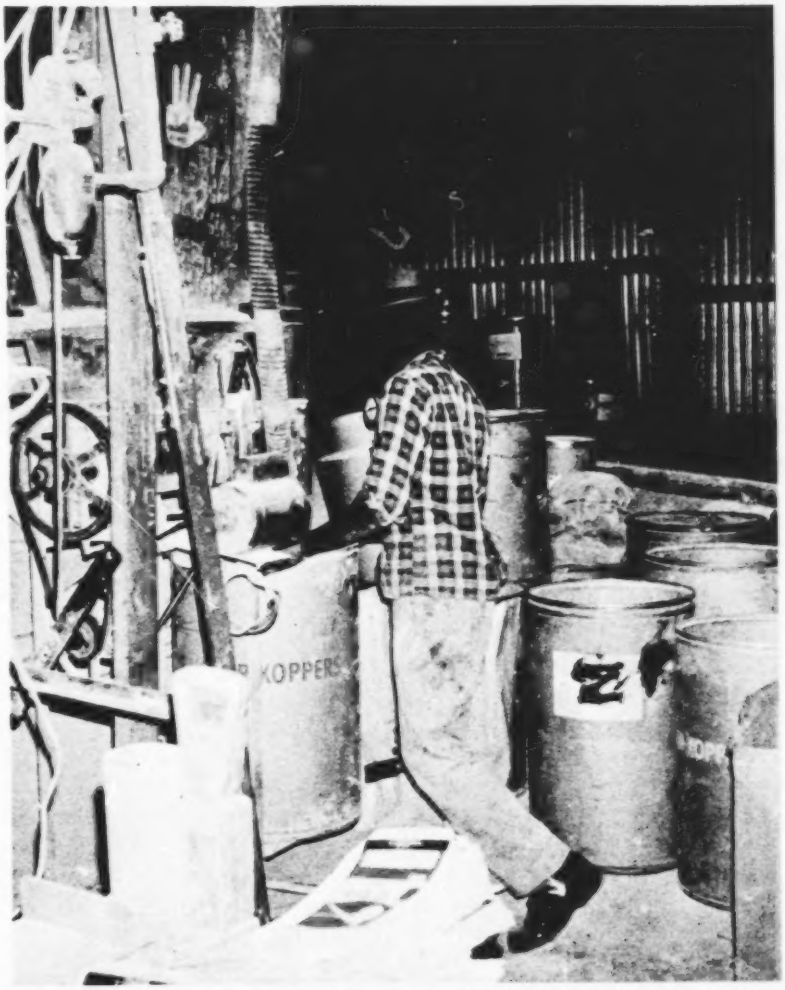
1. Avoid contamination and exposure.
2. Wear protective clothing.
3. Check equipment safety.
4. Read and observe label instructions.
5. Wash contaminated skin and change clothing.

During Application

1. Avoid inhalation of fumes.
2. Do not spray into wind.
3. Do not contaminate food, water, or utensils.
4. Avoid fire hazards.
5. Use recommended chemical and dosage.

After Application

1. Safe disposal of containers.
2. Wash hands thoroughly.
3. Bathe and change clothing daily.



Environmental exposure to pesticides in formulation plants is of primary concern.

PUBLICATION

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PESTICIDES PROGRAM
National Communicable
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PB 277 007

Pesticide Safety—All Users are Responsible

By ELDON P. SAVAGE and SAMUEL W. SIMMONS*

This is the second of two articles on pesticides and human safety by Drs. Eldon P. Savage and Samuel W. Simmons. Last month the authors emphasized that safe use of pesticides requires constant vigilance by everyone involved in the manufacture, transportation, storage, use and disposal of pesticide waste materials. This month's installment wraps up the full cycle with a discussion of pesticide storage and disposal of pesticide wastes.

Many accidental poisonings result from people ingesting pesticides which have been carelessly stored in food or drink containers. For example, six California farm workers died recently because they drank pesticides, mistaking them for water or another beverage. One worker was carrying two identical containers—one contained an herbicide and the other drinking water. He died after he drank from the wrong container.[1] In New Jersey last summer a worker nearly died when he drank from a soft drink bottle which contianed an herbicide.[2] Annually, small children are poisoned by drinking pesticides stored in soft drink containers. A recent study of 62 pesticide accidents involving all types of pesticide poisonings revealed that 65 per cent of those poisoning accidents occurred in children under six years of age.[3] Common places for storage of pesticides in the home are the catch-all storage

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area under the kitchen sink, the garage, or the basement. Many professional users fail to provide safe storage for pesticides during transportation and on business premises.

Pesticide poisonings have also occurred through contamination of foodstuffs by pesticides stored nearby. For example, in October, 1967, in Tijuana, Mexico, parathion which was stored in a warehouse near flour, sugar, and other foodstuffs contaminated some of these materials and subsequently caused at least 17 deaths and more than 300 illnesses.[4]

Storage Requirements

To prevent these types of accidents, all users of pesticides should initiate a safe pesticides storage program. A satisfactory storage program consists of at least the following important factors. Every user of pesticides should provide a safe area for their storage, and all pesticide storage areas should be locked. The storage area or cabinet should be dry and well ventilated, the temperature of the storage area should be kept above freezing. Pesticides should be stored in their original containers, and all pesticides containers should be adequately labeled and tightly closed.[5] Pesticides should never be placed in empty food or drink containers of any kind.

Another important facet of proper storage is the examination of pesticide containers for leaks or damage. When leaks or damage occur, the material should be transferred to a leakproof container, clearly labeled and dated with the same date as the original container. The old container should be decontaminated, made unusable and disposed of at an approved disposal site. The area should be inaccessible to children, animals and unauthorized personnel. Pesticides should be stored where food, feed and other chemicals can not be contaminated by them.

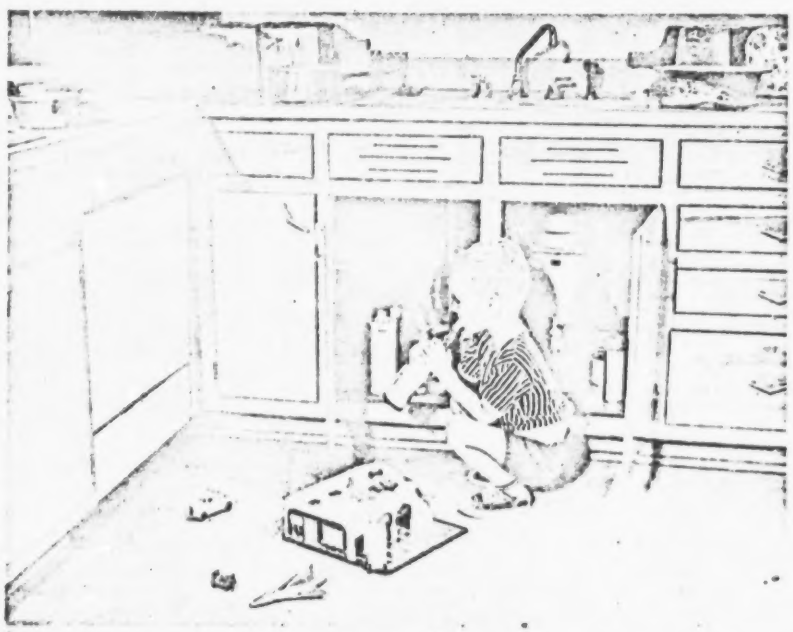
Professional users should compartmentalize their service truck bodies to separate chemicals from each other, and, more important, from the pest control serviceman-driver. Everything on the service truck should be kept under lock and key so supplies cannot be removed from the truck by anyone other than authorized servicemen.[6] Proper storage of pesticides could significantly reduce the number of pesticides accidents.

Waste Disposal

There are two major sources of pesticides wastes—the wastes from pesticides manufacturing and formulating plants and empty containers from both small and large users. The types of pesticide wastes to be disposed of vary in toxicity, persistency, and form. Solid and liquid pesticides wastes materials improperly disposed of may pollute the environment and eventually present a significant health hazard. A mounting problem of disposal of used pesticides containers has accompanied the increased gross sale of pesticides. Since more pesticides are packaged in smaller lightweight containers instead of in large drums, the number of pesticide containers has increased disproportionately. Problems of disposing of pesticides containers from both small and large users is increasingly important, since many fatal accidents have resulted from children playing with empty containers.

Disposal of large numbers of pesticides containers from farms and some pest control operations may present another problem, as adequate disposal will usually involve the storage of used containers on the individual business or farm premises prior to their collection for transport to the disposal site. All empty pesticides containers should be stored in locked, protected areas prior to transport to an approved disposal site.

The most hazardous containers to be disposed of are those which have held one of the more toxic organic phosphorous compounds such as parathion. A normal but *not* recommended procedure, which is used for disposal of pesticides containers on the farm and at many businesses, is the burning of paper pesticides containers in open fires. Many people burning containers stand by to make certain all containers are completely burned. Observations have shown that few of these people stand downwind to prevent inhalation of the fumes given off during the burning process. Used pesticides containers may create a serious hazard if



Pest control operators are in a position to advise against the home storage of pesticides in food or drink containers.

left in an unprotected area. This is especially true if the labels have been lost through exposure to moisture and the used pesticides containers are used for another purpose.[7]

Burn and Bury

Currently, the recommended common disposal practices for most types of residential and commercial solid wastes in the United States include burial (sanitary landfill) and incineration. The recommended procedure for sanitary landfill operation includes these following strict engineering practices in site selection, planning, design, and operation. Precautions must be taken so that underground and surface waters are not contaminated. The sanitary landfill operation should include provision for daily covering of the landfill with six inches of compacted earth, and the finished landfill should be covered with two feet of compacted earth.

Disposal by incineration involves burning of solid wastes materials at high temperatures between 1200 to 1800 degrees Fahrenheit. The incinerator design should also provide for disposal of the gases given off from the combustible materials, and disposal of the residual ash.

The disposal of liquid and solid pesticides wastes from formulation and manufacturing plants should be accomplished through sound engineering principles designed to meet the specific disposal needs of the individual operation. The following procedures are recommended to dispose of pesticides containers. Burning of pesticides containers should be conducted only in approved incinerators. In many instances the incinerator should be of specific design and engineered to handle the more hazardous pesticides. Usually a state or local health department can provide a list of approved incinerators or landfill sites in the area of their specific jurisdiction. Burial of pesticides containers should be done at approved sanitary landfills at other isolated sites where water contamination is not a problem. Studies have shown that when equipment operators at pesticides disposal sites wear prescribed protective devices, hazards to them are minimal.[8] Pesticides containers should never be used to fill ravines where the pesticides wastes will contaminate the underground or surface waters. If an individual disposes of his own pesticides containers, the containers should be crushed and buried and covered with two feet of clean compacted earth.

Re-Use of Containers

Under certain conditions formulators may be able to re-use large, non-combustible containers for repacking formulations. When this is done, a decontamination procedure should be used. The person conducting this procedure should wear protective clothing, including gloves, footwear, freshly laundered cap, coveralls, goggles or face shield. The decontamination procedure to follow can usually be obtained from the manufacturer of the specific pesticide and all recommended safety procedures should be followed closely.[9]

In the future, increased attention may be given to the packaging and sale of pesticides in easily disposable containers. The idea of soluble packages is not new, and recently a company has registered and is offering pesticides for sale in a soluble container. Each consumer package will make a gallon of finished spray. A major advantage of this approach is in the area of safety and convenience.[10]

Unfortunately, many of the solutions to the pesticides disposal problems have not been adequately researched and today's technical knowledge is inadequate. Limited studies are now underway to determine the mobility of pesticides in soils, the biological effect of various organisms on degradation of pesticides, and the development of improved incineration. Recently, a subcommittee meeting of the Federal Committee on Pest Control was held to discuss the whole area of pesticide disposal, and a new subcommittee is being formed under the parent committee on pesticide transportation and waste disposal.

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Aerial Application Accidents 1963 to 1966

An Analysis of the Principal Factors

George A. Reich, MD, and MAJ William H. Berner, USA, Atlanta

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The use of aircraft in agricultural operations is increasing. The accident rate for aerial applicators is second only to pleasure flying. An analysis of 1,328 aerial application accidents revealed the large majority of these occurred during the summer. Most of these crashes occur in southern and western states. Texas, California, and the Mississippi Delta account for 46% of all fatal crashes. Five plane manufacturers account for 83% of all crashes. Fire after impact is associated with fatal crashes. Safety-oriented engineering might well reduce the number of fatalities. Pilot factors are very important in the causation of these crashes. Lack of pilot experience at flying appears to be associated with fatal crashes. There is some evidence that the pilot's exposure to toxic chemicals may play a contributory or causal role in crashes of aerial applicators.

THE USE OF aircraft in agricultural operations has increased steadily since the close of World War II until at the present time over 1,040,000 flying hours are spent annually in the aerial application of pesticides, herbicides, fertilizers, and seeds.

The number of accidents associated with these operations has ranged from 300 to 400 per year since 1951, with the number of fatal accidents similarly ranging between 30 and 50. The accident rate for aerial application, expressed as accidents per 100,000 flight hours, is three times as high as other types of commercial flying, such as air taxi. This rate is second only to pleasure flying, a category under noncommercial flying. However, the increasing number of annual flying hours and the relatively steady number of accidents and fatalities has resulted in a progressive decline in the accident rates, from 51.7 total and 7.9 fatal accidents per 100,000 flying hours in 1951 to 31.1 and 4.2 in 1966. During the same period, all general aviations operations have shown a similar downward trend in rates, declining from 45.2 total and 5.2 fatal in 1951 to 27.2 and 2.7 in 1966.[1] The two main divisions of General Aviation, a term which includes all types of flying except airlines and military, are commercial (for direct financial return) and noncommercial (pleasure, personal transportation). Aerial application is a category under commercial flying.

In an effort to discover any similarities, trends, or patterns in aerial application accidents, we examined 1,328 accident briefs published by the Bureau of Aviation Safety, National Transportation Safety Board (formerly Bureau of Safety, Civil Aeronautics Board) for the years 1963 through 1966. These briefs, which are available to the public, contain the following items of information: cause-factor tables, date, location, aircraft data, injuries, flight purpose, pilot data, type of accident, probable cause(s), and presence of fire. Certain aspects of the man-machine-environment complex were tabulated and analyzed for their relationship to accidents and accident causes, the documentation of which should be an important step in any program of prevention. The format of the published briefs varied somewhat from year to year, and consequently some data were not available for all four years.

The inherent dangers of the flying itself will not be elaborated upon here. Billings[2] has amply described the problems of flying a noisy, vibrating, open-cockpit aircraft at the threshold of stall speed a few feet above the terrain with the physical obstructions and mental distractions of fences, power lines, buildings, and animals, while dispensing materials often highly toxic to man.

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Commercial sources and trade names are presented for identification purposes only. Their mention does not constitute endorsement by the Public Health Service or the US Department of Health, Education, and Welfare.

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Results

The Factor of Time.—Figure 1 shows the monthly distribution of accidents for the four years and clearly demonstrates the year-to-year consistency. Over 92% of the accidents occurred in the April-October period with the majority of these being in June, July, and August. Fatal accidents followed the same general pattern but did not show the same magnitude of summer increase. July was the peak for both fatals and nonfatals. This seasonal variation could not be explained objectively because data on the number of aircraft and hours flown were not available on a monthly basis. However, we assume that these operations, which are closely geared to agricultural demands for chemicals used as pesticides and fertilizers, are merely responding in numbers of aircraft and hours flown to the seasonal increase in agricultural activity, thus increasing the probability of accidents. This seems to be supported by the fact that the prevalence of mechanical failures, weather conditions, etc, as causal elements does not vary significantly during the year.

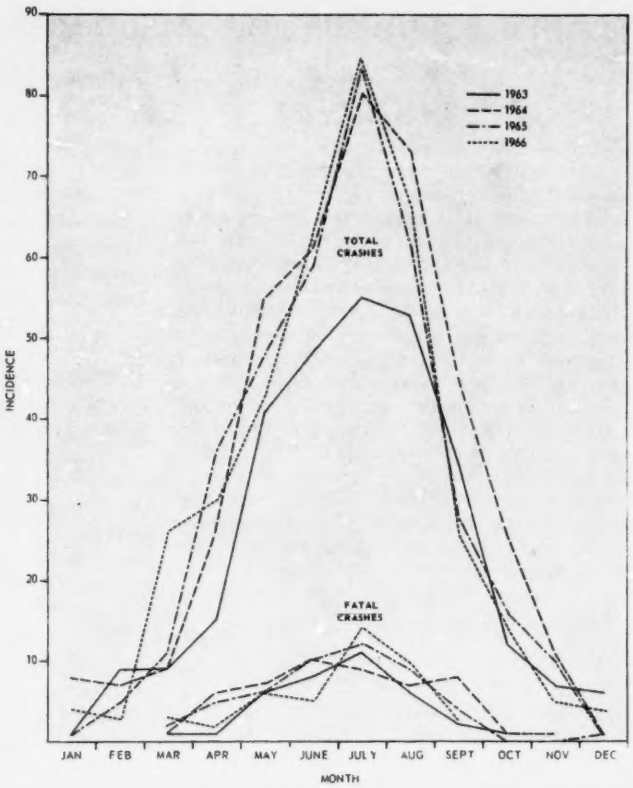

Fig 1.—Distribution of accidents of aerial applicators by month.

General aviation accidents show a similar seasonal fluctuation, but the July peak averages less than twice the December and January levels, whereas in aerial application accidents, the increase is about 20-fold.

Only the 1965 briefs included the time of day that the accident occurred. The hours from 6 AM to 6 PM accounted for 82% of all accidents; the majority of accidents occurred before noon. There were some accidents recorded from 6 PM to midnight, but very few from midnight to 6 AM. It is our understanding, however, that night aerial application operations using flood lights on the aircraft are on the increase. The time distribution of general aviation accidents is similar, with the bulk occurring during daylight, but the probability that an accident will result in a fatality increases sharply during the hours of darkness.

The Factor of Place.—Aerial application accidents are a nationwide phenomenon, occurring in all but three states in the years studied. Alaska, Connecticut and New Hampshire had no accidents; and Maine and Vermont each had only one accident during the four-year period.

The cases for each of the four years and for the years combined were tabulated by state and ranked by incidence. Table 1 presents the distribution and ranking of states in which there were at least ten accidents per year and at least 40 accidents for the four-year period. The ten states listed in the cumulative column accounted for 862 accidents, on 65% of all crashes of aerial applicators. These are southern and western

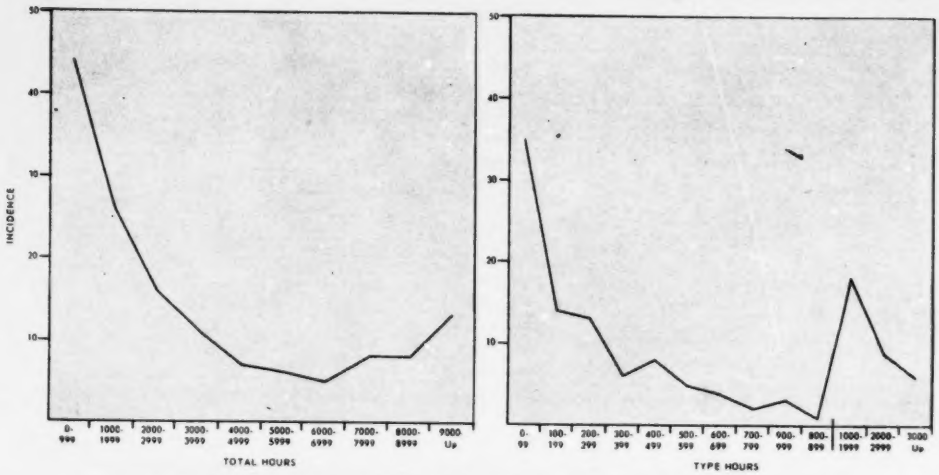

Fig 2.—Distribution of fatal accidents of aerial applicators by total and type hours.

states in which agriculture is a major industry, if not the primary one.

Table 2 presents fatal aerial application accidents ranked and distributed by states with two or more fatals per year and eight or more fatals for the four years. Sixty-two percent of the total number of fatal accidents occurred in the six states listed in the cumulative column. Of the six, North Dakota is unique in that it is the only state on the list which was not also in the top ten states for total accidents. Another interesting observation is the change in ranking among some states that occurs with respect to fatal and total accidents, eg, Arkansas. California and Texas lead the nation in general aviation total and fatal accidents as well as in aerial application total and fatal accidents. Arkansas ranks 25th in the nation in general aviation accidents but fourth in the nation in aerial application accidents. Furthermore, Arkansas ranked second in the nation in fatal aerial application accidents and first in the nation in case fatality rate for aerial application accidents for this four-year period.

The overall fatality rates were relatively constant for three years with 11.5% of accidents fatal in 1963, 11.0% in 1964, and 10.9% in 1965; however, in 1966, 13.7% of the aerial application crashes were fatal. There were marked variations in fatality rates from state to state. In Arkansas, 20.2% of aerial application accidents were fatal; in Mississippi, 17.2%; in Texas, 9.7%; in Louisiana, 8.4%; and in California, 8.2% were fatal. Three geographical areas, Texas, California, and the Mississippi Delta, accounted for over 46% of all fatal accidents. The Mississippi-Arkansas accidents were pinpointed on a map and found to occur in eastern Arkansas and western Mississippi in a cotton-growing area which is about 185 miles at its widest point and 220 miles at its longest. This small area stands out markedly from the rest of the nation in fatal aerial application accidents. It is worthy of note that a cotton crop may require as many as 20 separate aerial sprayings in a single growing season and that the pesticides required are often the toxic organophosphates. No such geographic concentrations of fatal accidents were apparent for general aviation. It is obvious then that in agricultural operations, the number of fatal aircraft accidents is not simply proportional to the total number of accidents in a geographic region. The Mississippi-Arkansas area needs further study to determine the causes of the almost "endemic" nature of fatal aerial application accidents there. Similar studies in other states with disproportionately high fatality rates, eg, North Dakota, would also seem indicated.

The Factor of the Aircraft.—The rank and distribution of the accidents are tabulated by manufacturers for each of the four years and for the cumulative period in Table 3. These

Table 1.—*Rank of States With Ten or More Accidents of Aerial Applicators

1963		1964		1965		1966		Cumulative (40 or More Crashes)	
Texas	50	California	59	Texas	61	California	50	Texas	206
California	31	Texas	53	California	42	Texas	42	California	182
Louisiana	25	Arkansas	28	Louisiana	29	Arkansas	19	Louisiana	95
Mississippi	21	Louisiana	25	Arkansas	24	Louisiana	16	Arkansas	84
Arizona	18	Florida	19	Mississippi	15	Georgia	16	Mississippi	58
Arkansas	13	Georgia	18	Georgia	15	Washington	12	Georgia	53
Idaho	11	Washington	17	Florida	13	Oklahoma	12	Washington	48
		Mississippi	14	Washington	13	Florida	10	Arizona	47
		Arizona	14	North Dakota	12	North Dakota	10	Florida	46
		Idaho	13	Alabama	11			Idaho	43
		Alabama	12	Nebraska	11				
		North Carolina	10	Idaho	10				
				Arizona	10				
				Montana	10				

* According to the Department of Transportation this is not to be used as an index of relative safety, since the element of exposure is not included.

Table 2.—*Rank of States With Two or More Fatal Accidents of Aerial Applicators

1963		1964		1965		1966		Cumulative (8 or More Fatals)	
California	4	Arkansas	9	Texas	6	Texas	7	Texas	20
Texas	3	Texas	4	Arkansas	4	California	5	Arkansas	17
Washington	3	California	3	Mississippi	4	Arkansas	4	California	15
Louisiana	2	North Dakota	3	Louisiana	3	Minnesota	3	Mississippi	10
Mississippi	2	North Carolina	3	California	3	Mississippi	2	North Dakota	9
Idaho	2	Oklahoma	2	North Dakota	3	Washington	2	Louisiana	8
Arizona	2	Louisiana	2	Colorado	3	Idaho	2		
North Dakota	2	Mississippi	2	New Mexico	2	Colorado	2		
New York	2	Nevada	2	Montana	2	Illinois	2		
				Kansas	2				

* According to the Department of Transportation this is not to be used as an index of relative safety, since the element of exposure is not included.

five manufacturers accounted for 83% of all the accidents. Piper aircraft were involved in 40% of the total number of accidents and Boeing (the A75 biplane) in 24%. These two ranked first and second for each of the four years. Since no information was available on the number of hours flown in aerial application annually by a given make of aircraft or the total number of that make of aircraft involved in agricultural operations, no conclusions could be drawn about the prevalance of Piper and Boeing aircraft in these accidents. It may reflect nothing more than the fact that Piper and Boeing are the most frequently used aircraft for this kind of flying.

Helicopters were represented in each of the four years. In 1963, they were involved in 9% of aerial application accidents, 13% in 1964, 9% again in 1965, but 16% in 1966. The leading state each year for these helicopter crashes was California. An interesting observation was that helicopters were responsible for 9% to 16% of aerial application accidents but represented only 3% to 4% of the total hours in aerial application. Thus, they appear to be disproportionately involved in accidents. Fatal crashes in helicopters were rare, only three occurring in the four years examined.

The fatal accidents were also ranked and distributed by manufacturer for the four years. Piper and Boeing ranked first and second each year in this category also, with a four-year total of 97 and 29 fatals, respectively. All other manufacturers had less than five or no fatals in each of the years examined. Piper and Boeing together accounted for 81% of the fatal crashes. Piper's involvement was 50% to 73% of the fatals annually with an average of 62%. Boeing ranged from 10% to 30% of fatals, averaging 19%. Thus,

Table 3.—Rank of Plane Makes Involved in Ten or More Accidents of Aerial Applicators*

1963		1964		1965		1966		Cumulative (40 or More Crashes)	
Piper	113	Piper	145	Piper	149	Piper	121	Piper	528
Boeing	63	Boeing	105	Boeing	74	Boeing	80	Boeing	323
Grumman	15	Bell	28	Grumman	32	Bell	34	Grumman	92
Snow	14	Grumman	27	Callair	25	Grumman	18	Bell	92
Callair	13	Callair	21	Bell	19	Callair	17	Callair	76
Stearman	11	Hughes	16			Hughes	11		
Bell	11								

* According to the Department of Transportation this is not to be used as an index of relative safety, since the element of exposure is not included.

it was noted that Piper aircraft were disproportionately involved in fatal accidents, ie, 62% of fatals, as compared to only 40% of the total application accidents. This predominance was present in each of the four years. In order to quantitate the significance of this observed association between Piper aircraft and fatal accidents, a test was done.

$$Z = \frac{f - Po}{\sqrt{\frac{Po\ (1-Po)}{n}}}$$ standard normal variable:

f = percent of fatal accidents in which a given plane make was involved,
Po = percent of total accidents in which the given plane make was involved,
n = the total number of accidents of which these were a part.

The results indicated a strong association between Piper and fatal accidents with a limit of confidence far in excess of 99%.

An evaluation of the fatality rates for each of the five manufacturers revealed that of the accidents in which Piper aircraft were involved, 18.4% were fatal, 9% for Boeing, 6.6% for Callair, and 2.2% for both Grumman and Bell. Thus, the likelihood of a fatality in a Piper aircraft accident appears to be twice that of a Boeing and eight times that of a Grumman or Bell accident.

In reviewing the cases, it was apparent that several models of Piper aircraft were used in aerial application. Three of these, the PA-18, PA-18A, and the PA-25, accounted for 83% of all the Piper accidents. The fatality rates for these models for each of the four years and for the cumulative period were determined. The rates for the years 1963 through 1966 were as follows:

PA-18 : 33%, 23%, 46%, 14%, overall 29%
PA-18A: 25%, 32%, 20%, 32%, overall 26%
PA-25 : 4%, 7%, 9%, 11%, overall 8.5%

Table 4.—Percent of Accidents Complicated by Fire After Impact by Make of Plane and Year

Plane	Year		
	1964	1965	1966
Callair	19	26	12
Piper	18.6	23	20
Grumman	11	12.5	11
Boeing	7.6	8.2	10

Table 5.—Parameters of Experience in Fatal and Nonfatal Accidents of Aerial Applicators, Age and Hours

	Fatal		Nonfatal	
	Mean	Median	Mean	Median
1963				
Age (yr)	36.7	35	36.81	37
Total (hr)	4633.46	3250	5369.77	4000
Type (hr)	1007.96	300	1417.52	350
AA* (hr)	1554.70	800	2564.25	1400†
1964				
Age	36.69	36.5	36.30	36
Total	2964.10	1500	4795.20	3686†
Type	794.71	298	1319.43	500†
1965				
Age	34.61	34.5	36.00	35
Total	2332.42	1335	4768.37	3200†
Type	437.00	250	1295.04	450†
1966				
Age	35.45	34.5	36.50	37
Total	4166.88	2340	4879.40	3500
Type	869.44	389.5	1663.35	500†
Combined				
Age	35.74	34.5	36.37	36
Total	3498.46	2000	4923.52	3500†
Type	783.70	298	1415.76	450†

* AA = hours of aerial application.
† Significant difference between means at 95% limit of confidence or greater (t-test).

It should be noted that the PA-18 and PA-18A are essentially the same aircraft, the only difference being that the PA-18A has some minor fuselage modifications which allow easier installation and removal of the dispensing tank. The PA-25 is an aircraft specifically designed and manufactured for use in aerial application operations.

Table 6.—Toxicological Data From 20 Fatal Accidents of Aerial Applicators in 1967

	Alcohol	C=O	Drugs	Cholinesterase ΔpH/hr	Miscellaneous
* 1	0	"Trace"	0	0.14	
* 2	0	X	X	0.46	
3	0	0	0	0.69	
* 4	6 mg% (blood)	14%	0	X	
* 5	X	18%	X	X	
* 6	0	40%	X	6.65 μol/ml/min	
7	X	X	X	X	
8	X	X	X	X	
9	. . X	X	X	X	
10	0	5%	0	1.04	
*11	0	0	0	X	15 ppb methyl parathion in blood
*12	0	0	X	0.55	Para-nitrophenol in urine
*13	X	X	X	0.55	
14	0	"Some"	0	0.95	
15	0	0	X	0.74	
*16	55 mg% (urine)	X	0	"50% of normal"	
*17	0	1.5%	0	0.48	Brain cholinesterase 0.06 ΔpH/hr
*18	X	X	X	X	High brain acetylcholine
19	X	X	X	X	
20	0	"Trace"	0	0.98	

* Abnormal result(s); X = analysis not done.

The important point to be taken from the above figures is that the chances of survival in PA-25 accidents are far greater than for the other models. Over the four years, the number of PA-18/18A accidents was seen to decline. It is hoped that this trend continues, because during the four years the PA-18/18A accounted for 40% of all fatal crashes of aerial applicators. Another trend which will bear watching is the rise in the number of accidents in the PA-25 and in its fatality rate, which rose from 4% in 1963 to 11% in 1966.

The Association of Fire and Death.—Death in almost all aircraft accidents is caused either by the crushing and piercing injuries associated with impact or by the effects of fire, including burns, asphyxia, and carbon monoxide poisoning. The cause of death was not listed in the briefs of accidents examined, but the years 1964 through 1966 had notations regarding "fire after impact." Therefore, the variable of fire was examined for its significance in these accidents.

In 1964, 12.4% of the accidents were complicated by fire, 16.7% in 1965, and 13.4% in 1966. There is an apparent yearly consistency of postcrash fire complications. This same evaluation for fatal accidents revealed fire after impact prevalence to be 47% in 1964, 70% in 1965, and 40% in 1966, showing a rather wide variation from year to year. However, it was noted that fire was three to four times more prevalent among fatal accidents than it was among nonfatals. Two possible explanations for this are (1) The crash forces are so great that the pilot is killed, and the fire is incidental; (2) The fire itself is causally related to the pilot's death. In either case, the association between fire and death is strong.

A determination was then made of the prevalence of fire after impact among the various makes of planes. This is shown in Table 4. Callair crashes had the greatest propensity for fire in 1964 and 1965 with Piper second. These positions were reversed in 1966. However, it must be pointed out that during this three-year period, there were only 63 crashes in Callair planes; thus, these numbers may be too small to determine an accurate prevalence of fire for Callair models. Fire was extremely rare with helicopter crashes.

In 1964, Piper was involved in 56% of total crashes complicated by fire and in 70% of fatal crashes complicated by fire, which is greater than one would predict from Piper's involvement in overall total and overall fatal accidents (37% and 63%, respectively) for

that year. In 1965, Piper was involved in 62% of crashes complicated by fire and 81% of fatal crashes complicated by fire, again greater than expected from Piper's involvement in total crashes (42%) and in fatal crashes (73%). In 1966, Piper was involved in 58% of crashes complicated by fire and 47% of fatal crashes complicated by fire which is also greater than expected from Piper's involvement in total crashes ([38%] but not dissimilar from Piper's involvement in fatal crashes [50%]). The other manufacturers had too few cases of fire to determine meaningful percentages when broken down into fatal and nonfatal categories for each of the years.

A further evaluation of the main Piper models showed the following fire rates:

Model	Percent of Total Accidents Complicated by Fire	Percent of Fatal Accidents Complicated by Fire
PA-18	17.2	38
PA-18A	13.1	39
PA-25	19.5	82

Thus, fatal PA-25 crashes were strongly associated with fire. This seems to indicate that although a crash in a PA-25 is less likely to be fatal when compared to the other models, fire, when it does occur, may be the major hazard. On the other hand, accidents in the PA-18/18A are more likely to be associated with death by crushing or piercing injuries. One may infer from this that if the fire hazard could be reduced, the fatalities might decrease sharply to an even lower level. Bruggink et al[3] have reported that safety-oriented engineering can produce successful improvements in crashworthiness design.

In summary, one may conclude that Piper is disproportionately involved in fatal crashes due to the records of the PA-18/18A. Use of these models, however, is apparently on the decline. The PA-25 seems safer in a crash than the other two models, but its fatality rate is increasing. The occurrence of fire after impact is strongly associated with fatal outcome. Fire after impact is more prevalent among Callair and Piper planes than the others. It does not appear to be a problem with helicopters in this kind of flying. In 1966, Piper was involved in a smaller proportion of fatal crashes than previously while Boeing rose sharply. The overall fire rate from year to year does not seem to vary much except with fatal crashes. Helicopters account for a greater proportion of crashes than expected, but death and fire are very infrequent.

The Factor of the Pilot.—Pilot factors were listed as causative in 53% to 70% of total accidents and 72% to 90% of fatal accidents for each of the four years. The pilot factors most commonly listed were the following: (1) failed to obtain or maintain flying speed; (2) failed to see and avoid objects or obstructions; (3) misjudged clearance—altitude, distance, and speed; (4) inadequate preflight preparation and planning; (5) improper operation of flight-powerplant controls; (6) selected unsuitable terrain for takeoff and landing; (7) inattention and mismanagement of fuel supply. These "causes" are merely descriptive terminology which give no clue to the reasons for the pilots' errors. The underlying causes of these pilot errors are generally unknown.

Alcoholic impairment of the pilot was listed only four times during the entire four years. Since blood alcohol determinations are routinely sought in fatal crashes, these figures indicate that alcohol is seldom identifiable as a problem in these operations.

In an effort to examine objective parameters of pilot experience in both fatal and nonfatal accidents, a determination was made of the following indices: (1) age of pilot, (2) total hours of flying, (3) hours in type aircraft, and (4) hours in aerial application. These statistical data for each of the four years and for the years combined are presented in Table 5. First, it was observed that pilot age was not significantly different (by t-test) in fatal vs nonfatal crashes in any of the years. Pilot experience, as measured by total hours, was less by mean and median comparison among fatal crashes than among nonfatal crashes in each of the four years. This difference was significant only in 1964 and 1965. Experience, as measured by time in aircraft type, was less by mean and median comparison among fatal crashes than among nonfatal crashes in each of the four years. This difference was significant in 1964, 1965, and 1966. Hours of experience in aerial application were published in the briefs for 1963 only. This parameter was

significantly different between fatals and nonfatals. Thus, there was an overall observation that pilot age made no difference in fatal vs nonfatal, but that the other three parameters appeared to indicate that relatively less experienced pilots were more likely to be involved in fatal crashes. The reason for the inconsistencies in these from year to year related to statistical significance was not apparent until the hours for pilots in fatal crashes were distributed by groups. This is shown on Fig 2. This type of distribution does not lend itself very well to mean or median comparison, since the few cases with a high number of flying hours offset such a large group of those with few hours, and the standard deviation of this type distribution is very large. This does indicate, however, that most of the fatal accidents occurred among the less experienced, but that even some of those pilots with a large number of either total hours or hours in type aircraft are involved in fatal crashes each year.

Similar experience data were not available for the total population of aerial applicator pilots, so no statements can be made regarding those who crash vs those who do not.

A vertical comparison of the medians of type hours in Table 5 revealed a consistency from year to year in both fatals and nonfatals. Means varied somewhat more for type hours among fatals and nonfatals. Total hours for nonfatals each year were rather consistent by both mean and median comparison. However, among the fatals, both mean and median comparison varied considerably because of the varying number of more experienced pilots involved in fatal crashes from year to year. Their total hours had a great effect on the mean, and their number had an effect on the median.

In combining the data for all four years for each of the indices to obtain a larger, more representative group of pilots for analysis, the following observations were made: (1) When comparing means and medians, there was a significant difference in experience, as measured by total hours, between pilots involved in fatal as opposed to nonfatal crashes. (2) The same was true for hours in type. (3) Age of the pilot was not a factor. These observations indicate a greater tendency for the less experienced pilots to be involved in fatal crashes. However, a fatal accident ends experience, so there may be some statistical bias in favor of pilots with fewer flying hours having fatal crashes.

Pilot factors were found to be of importance in the 17 fatal accidents which occurred in Arkansas between May 1964 and July 1966. An analysis of these cases showed that time, plane type, and fire involvement were the same as with other fatal crashes. Pilot factors were responsible for all of the accidents except one, which was caused by the installation of the wrong type of propeller. Pilot experience by total hours had a mean of 2,790 and a median of 1,200, both of which are less than the overall mean and median of total hours in other fatal crashes. Pilot experience by type hours had a mean of 470 and a median of 262, both of which are less than the overall mean and median in other fatal crashes. This seemed to indicate that lack of pilot experience may have had some relationship to these crashes.

Bureau of Aviation Safety—Pesticide Program Investigations.—Recognizing that pilot factors are of significant causal importance in aerial application accidents, an agreement between the Bureau of Aviation Safety and the Community Studies Section of the Pesticides Program was developed as of Jan 1, 1967, whereby fatal crashes of aerial applicators would be jointly investigated with special emphasis on the role of toxic agents. It was apparent from the briefs that alcohol and carbon monoxide were infrequently involved in these accidents, and even more infrequently was pesticide exposure or intoxication listed as a causal element. This latter observation may indicate a general unavailability of proper testing and interpretation which is necessary to determine the type of pesticide involved and the effect of exposure. Some cases were found in which toxicological data regarding pesticide exposure had been ignored or clearly misinterpreted. Dille[4] and Billings[2] have pointed out the toxicological problems associated with pesticides. In 1964, only one case in the briefs mentioned pesticide exposure; in 1965, seven cases mentioned such exposure, and one case mentioned "blurred vision." In 1966, there were four cases of reported pesticide exposure, and two others had cholinesterase levels below the lower limit of normal.

Although materials other than pesticides may be dispensed from aircraft, it was our objective in these cooperative investigations to document any possible link between toxic chemicals and pilot error accidents, for it is obvious that if pesticides did play a role it could only be through their effect on the pilot.

Since the inception of the program, we have received preliminary data on 20 fatal crashes of aerial applicators which occurred in 1967. This is represented in Table 6. In four of these cases, no toxicological examination could be obtained. On the remaining 16, at least one laboratory test was done. Eleven of these (69%) had at least one abnormal test result. Only two had measurable levels of alcohol. Three had significant levels of carbon monoxide; five others had at least trace amounts, but these are not considered to be abnormal. Higher levels may be found in cigarette smokers. In 12 cases tested for cholinesterase activity, six had levels lower than normal, indicating the probability of exposure to organophosphate pesticides. Four of these cholinesterase levels were significantly depressed indicating excessive exposure to organophosphates. One had 15 ppb of methyl parathion in his blood, one had para-nitrophenol in his urine (indicating exposure to any one of five organophosphates), and one had high levels of acetylcholine in his brain tissue. Thus, eight of the 16 tested showed evidence of organophosphate exposure, and results from five of these were compatible with excessive exposure. Accurate interpretation of brain acetylcholine levels will have to await further research.

Case 17 in Table 6, reported by Irma West, MD, of the California Department of Public Health, reflected a death due directly to the toxic agent, since the pilot's exposure occurred secondary to the crash. The pilot was not critically injured in the crash, but was splashed with tetraethyl pyrophosphate (TEPP) and mevinphos (Phosdrin) and died of organophosphate poisoning 20 minutes later.

When analytical results are decidedly abnormal, there is little difficulty in recognizing that severe pilot impairment could exist. However, with results which are only slightly abnormal, it is almost impossible at our present state of knowledge to determine the degree of physiological impairment which might result and the effect which this would have on flying skill. This effect might have no hazardous import until the pilot is faced with some contingency which, because of his low speed or low altitude, gives him little time to perceive, comprehend, judge, and react appropriately. At this point, even slight impairment might have disastrous consequences.

We hope that by collecting a much larger amount of toxicological data on aerial application crashes, the dividing line between abnormality and significant abnormality will become more precise. The community studies are also analyzing blood and other tissues from these fatalities to determine the types and quantities of organochlorine pesticides which are present.

Summary

One thousand, three hundred and twenty-eight cases of aerial application accidents involving 1,337 aircraft (including nine collisions between aircraft) and resulting in 159 deaths during the years 1963 to 1966 were analyzed. The factors of time, place, aircraft, and pilot were found to be associated with these accidents in a consistent and characteristic way. Specific studies are needed to determine why certain geographic areas, certain aircraft makes and models, and certain categories of pilot are more likely than others to be involved in accidents and fatalities. Present determinations of probable cause in pilot error accidents are actually descriptions of the penultimate events in the accident sequence rather than explanations of why the accident occurred. Underlying causes must be found if preventive measures are to be formulated.

Mr. Gerald Metter and Mr. Thomas Mason of the Pesticides Program, National Communicable Disease Center gave statistical assistance in this study.

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PESTICIDES INTELLIGENCE IN RELATION TO OUR ENVIRONMENT

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The ultimate objective of human effort and technology, including conservation, is to improve man's welfare. However, advances in one field of endeavor are not always compatible with another. Over the span of the last 25 years there has evolved among the scientific community awareness of a proliferation of synthetic and natural chemical agents which increasingly pollute man's environment.

Development and widespread use of low-cost modern synthetic pesticides have greatly augmented food and fiber production as well as aided in the control of insect-borne diseases. In contrast to these benefits, the use of pesticides has resulted in significant pollution problems involving the health of man, marine and wildlife, and domestic animals. Contamination of air, soil, water, food, and other elements of the environment by industrial and community wastes, acid mine wastes, exhaust fumes, and

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combustion products and other pollutants have compounded this problem.

Relative to pesticides and man's health, substantial data exists on the acute toxicity of pesticidal compounds used most widely today. Too little is known, however, of adverse health effects which may be occurring from continuous exposure of the general population to low-level amounts of pesticides as they are received in food, water, and air.

For example, Grzenda and his co-workers (1), found that water quality can be adversely affected by the persistence of herbicides and their composition products and can subsequently alter that environment. Some of the degradation products may not be phytotoxic, as in the case of one of the degradation products of 3-aminotriazole, but may be incorporated into the cellular protein of some bacteria and in this way make itself a kind of "intra-cellular pollutant."

The Executive Branch of the Federal Government has already begun coordinating Federal agency efforts to control environmental pollution. A meeting comprised of representatives of the U. S. Department of Agriculture; Department of the Interior; Department of Health, Education, and Welfare (both Food and Drug Administration and the Public Health Service), was devoted recently to research and information needs on weeds and their control (2). Herbicide methodology, tolerances, water quality as related to conservation, weed control problems, and health aspects of herbicides were discussed. The Department of Agriculture's current research relates to (1) the control of aquatic weeds for the betterment of recreation and water conservation, and (2) the fate of herbicides in the total environment with considerable emphasis upon water. Spokesmen for Department of Interior, representing the Federal Water Pollution Control Administration, summarized needs for research and information on such questions as: (1) Will these herbicides move to the oceans and accumulate in offshore waters? (2) Do these herbicides affect photosynthesis and other biological processes in marine organisms? (3)Will they upset the oxygen-carbon dioxide balance and subsequently adversely influence the productivity of the marine habitat? They are searching for new ways to detect herbicides in water which will allow detection at the part per trillion level. These three Federal Departments are cooperating closely in the area of environmental research. A suitable water ecosystem will depend upon future research and the application of the results obtained for controlling water pollution.

Meanwhile, the Public Health Service will continue its concern with other biological hazards that are being imposed upon the environment. Herbicides have been used for eradication of weeds and plants along irrigation canals, reservoirs, and waterways (3). There are areas of basic research dealing with herbicides contaminating shellfish waters which eventually receive the residues from water weed eradication programs. Appropriately sensitive and specific analytical techniques must be developed to help combat this kind of contamination. However, these techniques need to be relatively simple so that data can be readily collected. The biological effects of herbicides upon shellfish and the associated accumulation within their systems of substances toxic to organisms situated higher in the food chain has to be thoroughly investigated. Also, persistance and fate of herbicides and their degradation products need to be known and above all tolerence limits for these established.

The area of greatest interest to many of us here today is water conservation, and President Johnson (4) has begun an austere program designed to eventually clear up our waterways. The President has said that at this time, rivers, lakes, and estuaries are receiving great quantities of industrial and domestic wastes that are too burdensome to breakdown in the ordinary life of the water. These pollutants are reentering domestic and industrial water supplies and are killing fish. They pose hazards to both human and animal life. We see that we can corrupt and destroy our rivers, our forests, and the atmosphere itself in the name of progress. There is another course but it is more expensive today and more demanding. Down this course lies a natural America restored to her people and the promise is clear rivers, tall forests, and clean air; a sane environment for man.

In the struggle against environmental pollution, a primary concern of the Public Health Service is the potential hazards of herbicides to human health. Approximately one billion pounds of pesticides were used in the United States in 1965, one-fourth of which were herbicides. These compounds were applied over an area exceeding 70 million acres (5). Because they are generally postulated to be of low mammalian toxicity, health problems with herbicides are ill-defined although acute occupational and accidental exposures have been reported.

Case studies have shown that 2,4-D poisoning can result in loss of appetite and weight, aching and even partial paralysis of the extremeties (6). The safe handling of all herbicides becomes a matter of urgent concern when it is realized that the nitro compounds, such as dinitro-orthocresol, are 10 times as toxic as 2,4-D, and that the addition of chloride to 2,4-D increases the toxicity 5-fold (7).

Further, it is known that the interaction among different pesticides can produce adverse health effects of increased severity. This phenomenon, known as potentiation, is associated with the carcinogenic or cancer inducing qualities of pesticides. For instance, one of the chemical growth regulators (isopropyl-N-phenylcarbamate) which is used to inhibit potato sprouting is not carcinogenic in itself. However, when fed to experimental animals, and when the skins of these animals are painted with croton oil in olive oil, skin tumors are produced (8, 9). Such is not the case when these compounds are adminis-

tered separately.

Other problems that have arisen in the past which could endanger users, livestock, and consumers of treated crops have been outlined by Harris (10). Upon analysis, extraneous insecticides other than those on the label were found in the containers and some were found after injuries to livestock had occurred. He found four general areas which indicated poor quality control: (1) batching errors -- too much reliance upon the batch formula and not upon chemical analysis of the final product, (2) labeling errors -- affixing the incorrect labels to the containers for marketing, (3) improper cleaning -- failure to clean batching equipment, and (4) poor process control -- minor changes in manufacturing processes.

To help guard against these errors, the Public Health Service was authorized by the Federal Insecticide, Fungicide, and Rodenticide Act to establish a Pesticide Registration unit in its Office of Pesticides. The unit reviews proposed registrations and labels of pesticide formulations. Particular attention is paid to label accuracy and the precautionary statements. The Public Health Service Pesticide Registration unit also carefully reviews the labels for statements concerning toxicity, recommended dosages and applications for the pesticides, as well as possible environmental persistence and degree of environmental contamination.

In the interest of basic research, the Public Health Service Office of Pesticides has sponsored work on aminoacidemia, characterized by an abnormally high quantity of amino acids in the blood plasma. This condition has been associated with heavy exposure to a wide range of pesticides (11). Aminoaciduria, the same condition involving amino acids, or body protein material in the urine, has also been attributed to the same kind of exposure. These preliminary studies imply the possibility of adverse physiological effects of pesticides upon vital organs and enzyme systems. Much work still remains to be done before unequivocal conclusions can be reached.

The Public Health Service, however, is also responsible for a broad scope of environmental problems, and our viewpoints must be tempered by cognizance of ill effects caused by natural environmental contaminants such as pollens and other aero allergens (12). Weed eradication, such as for ragweed, if mounted on a large scale should be helpful in alleviating human suffering from this allergic disease or its more serious counterpart, asthma. There is, of course, a paucity of epidemiological data on the allergies in general which includes a spectrum of problems: why some people are allergic to noxious weeds; how the response to the weed pollen can be aborted; the relationship of these weed allergies to infectious diseases and emphysema. The solutions to these problems may be forthcoming through basic research in areas of immunochemistry, immunology, and allergy.

In the extensive use of herbicides to control weed problems, one is confronted not only with human response to aero allergens or antigens but the probable sensitization to herbicidal chemicals. Randolph (13) has drawn attention to the fact that those of the general population who are highly susceptible to agricultural chemicals will invariably react to 2,4-D sprays and certain other chemical herbicides. Hence in community spray programs it is mandatory that such persons be notified in advance so that they can escape the spray zone or insulate themselves from contact by inhalation of these chemical allergens.

Currently, the Public Health Service's pesticide program is being consolidated with the Toxicology Branch of the Communicable Disease Center in Atlanta, Georgia, to provide increased emphasis upon total chemical epidemiology, toxicology, and intelligence concerning the incidence and cause of human disease. Chemical pollutants affect all of us and a concerted effort combined in this way will provide information leading toward a more healthy environment.

A major part of this program is the development of a Pesticide Intelligence System which represents a comprehensive national information network on the health effects of pesticides and other chemical contaminants. In our development of this system, primary attention will be given to the acquisition of information on the toxicity and pharmacology of pesticides as they affect man, including monitoring of pesticide levels in the bodies of people and their environment.

The intelligence retrieval function will involve the collection of literature and data and provide for collation, storage, and quick retrieval of all information input. Data will be available for dissemination to the scientific community, industry, policy makers, and the general public whenever it is of interest.

This monitoring system has as its primary objective the acquisition on a continuous basis of all available scientific data on the kinds and amounts of pesticides retained in the tissues and organs of people following dietary, atmospheric and other types of exposures. Plans have been made to establish within the current year a small nucleus of monitoring stations to collect human tissues and body fluid samples (adipose, liver, kidney and brain tissues, and blood and urine) for pesticide analyses. Eventually this network will be expanded to form a nationwide monitoring system. Samples are to be collected in cooperation with physicians, hospitals, and local medical examiners. Histories of pesticide exposures will be obtained from individuals sampled.

These data will then be continuously correlated with epidemiological and toxicological research findings to identify any existing or potential dangers to human health which may be associated with present or future use and exposure to pesticides.

To implement the entire program concerned

with environmental pollution, President Johnson proposes to unite state and federal efforts so that the best use is made of the manpower and technical expertise that we have to offer. This technical expertise is just beginning to make its weight felt.

In summary, technological advances have enabled us to produce more food and fiber than ever before, but we have also threatened ourselves with extensive environmental contamination. This impending contamination of the environment is also a threat to our health. It is a paradox that man has done so much to lessen his physical efforts -- thus conserving human resources -- at the expense of ruining and destroying the natural resources. We have the weighty responsibility to provide food and fiber and to forestall epidemics through the use of pesticides, but at the same time to preserve the natural beauty of the world.

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SUMMATION OF COMMUNITY STUDIES ON PESTICIDE WORKSHOP

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H. F. Kraybill, Ph.D., Office of Pesticides, BSS (EH), Public Health Services, and Milton J. Foter, Ph. D., Program Office, BSS (EH), Public Health Service, provide a summary of current data on the use of pesticides.

The Working Conference on Pesticides in the first day sessions had the proper orientation provided for all project participants and observers by the emphasis placed on the role of PHS in federal programs on pesticides and the concepts advanced essential in planning all phases of these comprehensive studies in various communities. Recognizing the fact that there has been some varying philosophies on the need for pesticide use surveys in the discussion of program objectives and projections, major attention was given to the reasons for conducting use surveys and the relationship of use surveys to assessment of exposure. It was predicted that an outgrowth of developing such information would be the establishment of mathematical models for delineation of exposure from all sources. It was felt that at this point in time this information would also be useful in correlation of specific environmental stresses or exposures to any disease states revealed in the study and would also provide a basis for implementing remedial measures. Whereas the need for wide scale monitoring is appreciated, it was assumed that after a time span of five years sufficient data would be accrued and that this phase of the program might plateau or decrease in effort. A longer period of time was believed necessary to adequately pinpoint some associations between chronic exposure and adverse health effects.

The guideline in the epidemiological investigations do not appear to be clearly defined at this moment. However, in preliminary research on some of the more advanced projects, the direction of the exploratory work seems well defined and may provide indeed some breakthrough in resolution of this complex problem. The statement of the problem is quite broad and the effect category is limited only in that one must hunt for ill effects. In an attempt to delimit the problem one is confronted with the fact that we are dealing not with a single stress but a multiple stress in terms of all pesticides and multiple effects as all illnesses. In the development of minimum or basic guidelines it was stated that we must search for a case where there appears to be a clear cut identification of a disease or diseases in terms of exposures. As one approach, wholesale searches for mass data in Human Population Laboratories (HIP, Permanente Plan, etc.) may indeed be useful. Longevity may be one parameter in such a search or other clinical entities could well be anemias, leukemias. One basis criterion may be mortality data and certainly the mortality experience of high exposure groups could give important leads. There seems to be several directional approaches going from symptoms to exposures or conversely from exposure to symptoms. Some investigators emphasized the following categories for epidemiological investigations (1) acute mortality, (2) acute non-fatal and (3) death experiences of the highly exposed. In extension of these one may consider biochemical changes associated with exposure conditions. In the preliminary phases it was felt that one might concentrate on small groups with an identifiable symptom of disease and ac-

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crue larger numbers of cases in population, if possible, with time. Another intriguing possibility is the epidemiological study of pregnant women and ultimate birth defects in follow-up through the exposure during household use of pesticides.

Another limitation which might be imposed in the epidemiological studies is that of restricting the types or numbers of pesticides for study, oriented around broad categories of mortality and morbidity. Another approach is to limit the illnesses to be studied. In essence, it was concluded that for the present there are not sufficient leads to indicate a major concentration of effort on one disease or any group of specified diseases.

In the panel discussions on epidemiological approaches certain salient factors were discussed. Reiterating the emphasis earlier, it was mentioned that the relative importance of negative versus positive effects must not be overlooked and proper diagnosis must be made in all cases to establish a cause and effect relationship. From various investigators' experience certain clinical entities were suggested for consideration such as EEG changes, blood clotting alteration, visual difficulties and muscular effects in OP compound exposure.

Some brief descriptions were given of the intramural and operational programs of Office of Pesticides both at Washington headquarters and Perrine, Florida, laboratory.

The broad mission of the Pesticides Intelligence System appeared to provide an important suppertive role on a national level to contractors' projects and PHS intramural research effort. The availability of information in form of reports, reprints, abstracts and the planned data retrieval operation based on interagency input will be useful to all those engaged in community study projects. A discussion of the registration activity supported by OP — PHS traced the development of this program from USDA under FIFERA, the Miller Amendment of FIFERA (1954) to the recent implementation of an Interdepartmental agreement. The role of registration in these contractual projects was delineated.

It is evident that considerable progress has been made in getting agreement on what type of use survey form or questionnaire should be adopted. It was concluded that a survey form would soon be available for SOS clearance and ultimate application to the projects.

Commentaries of participants at this workshop indicated that the progress reports of the contractors was one of the highlights of the meeting. Considering the fact that many difficulties and obstacles intervened, the tempo of activity has increased and visible accomplishments provide much optimism for forecasting the future developments. Contract or project directors have indicated that the interchange of progress reports and the annual workshop, such as the one here in Denver, are quite informative and essential to stimulation of their own work on monitoring, toxicology, biochemistry and epidemiology.

The Florida studies emphasized the importance of case findings which provide an epidemiological base for extension to large population searches on renal tubular disease. The detection of acute intoxications, especially those with OP compounds, have not only revealed important findings as to acute espisodes but are suggestive in terms of chronic effects. In fact, the detection of such intoxications is based upon a high index of suspicion, community knowledge, clinical knowledge and scene investigation with adequate laboratory procedures. The phosphorous reabsorption index and the kidney dysfunction observations have provided important clues which may reflect an irreversibility in man. It may be anticipated that such important clinical-biochemical findings may be uncovered elsewhere in the various projects.

The comprehensive studies on p-nitrophenol excretion following varying levels of parathion exposure have been important facets of the Dade County intensive studies. As work continues here and elsewhere, it is hoped that work to elucidate other metabolites will provide other biochemical markers not only to monitor exposure but which will serve as indices of physiological and pathological aberrations.